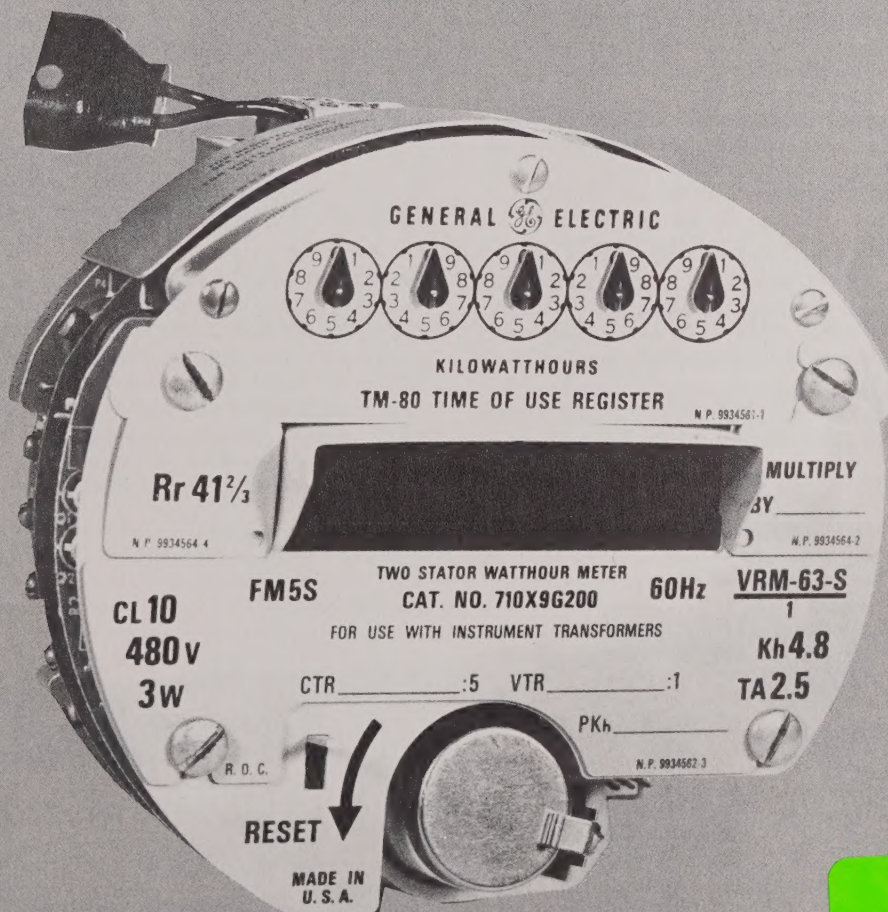




INSTRUCTIONS

GEH-2792

TYPE TM-80 TIME-OF-USE REGISTER



MP MASTER



MA32646

GENERAL  ELECTRIC

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TYPE TM-80 TIME-OF-USE REGISTER

INTRODUCTION

These instructions cover the operation, installation, maintenance and testing of the Type TM-80 Time-of-Use Register plus its associated components -- the TOU wathour-meter cover assembly and the register carry-over battery.

A wathour meter with a TM-80 register carries an "RM" designation because of the timekeeping and demand capabilities of the register. For example, a Type I-70 wathour meter becomes a Type IRM-70 meter and a V-63 becomes a VRM-63 meter. See Fig. 1. The TM-80 register is available on most General Electric wathour meters having magnetic suspension (see "Meter Types" below).

The register is a microprocessor-based device with battery-powered carryover capability. It is programmable for a period of five years, this being accomplished by the portable programmer through a communication port in the wathour meter cover. The TM-80 has the ability to register kilowatthour consumption and maximum demand during three independently programmable daily periods and four different seasons, as well as to display the date and time.

SPECIFICATIONS

METER TYPES

The Type TM-80 TOU register mounts on the following General Electric wathour meters:

1. Type I-70-S single-phase meters
2. V-60 family of polyphase meters; also Types V-63-2A, V-64-2A and V-65-2A totalizing meters
3. DS-50 and DS-60 families of switchboard meters

Each meter must be equipped with a cover taller than the standard meter cover. The new cover, made of LEXAN® polycarbonate resin, contains a communication port and a combination battery access port/demand reset mechanism. See Fig. 4. The register design allows for mounting a standard General Electric pulse initiator, in addition to the TM-80 register, on any of the above meter types.

Conversion kits are available for field installation of the TM-80 register on any of the meters listed above.

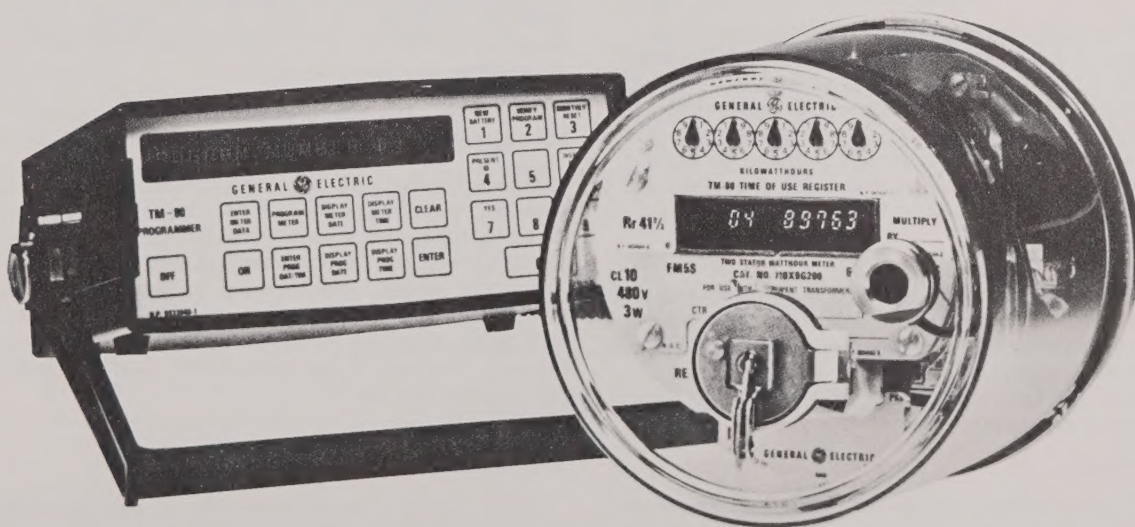


Fig. 1. Type VRM-63 TOU meter with programmer.

ENVIRONMENTAL

The Type TM-80 register is intended to function under the cover of meters in their normal operating environments. The operating ambient temperature range (inside meter cover) for the register is -40 C to +85 C. The humidity range is from 0 to 100 percent relative humidity, noncondensing.

ELECTRICAL

Supply Voltage:

The register can be supplied with a transformer having a nominal input voltage of 120, 240, 277, or 480 volts at 60 Hz. The operating voltage range is from -20 to +15 percent of the nominal voltage.

Burden:

The register burden is less than five VA at 240 volts nominal voltage.

Surge:

The register supply voltage terminals will withstand surges of 1.5 microseconds rise and 40 microseconds delay with a peak of seven kV maximum.

Hi-pot:

The register supply voltage terminals will withstand 2500 volts rms maximum with respect to the register metal frame. The communication port in the meter cover and the optional rate indicator and load control outputs will withstand 1000 volts rms maximum with respect to the register metal frame.

Battery Test:

A battery test is automatically performed each day at midnight. For this test, a load of approximately 2 mA is applied, while the battery voltage is checked. A battery voltage of less than 4.5 volts causes the test to fail, and the register will display the battery error code. The battery test can also be manually initiated by activating the magnetic display switch using a magnet rod. The switch is shown in Fig. 5.

Battery Carryover:

The field-replaceable battery will maintain register timing and memory for a minimum of 40 days cumulative time over the expected 5-year minimum operating life of the battery. The register electronic circuitry measures the total cumulative time in minutes of the battery on carryover.

Time Base:

The primary time base is the 60 Hz line frequency available during normal operation. For power outages, the secondary time base is a crystal with a maximum timing error of 0.01 percent of the outage time.

Pulse Input:

Pulses are generated in the register optics assembly (Fig. 2) from a shutter disk with photoelectric sensing. A standard of one input pulse per meter disk revolution is obtained with a two-slot shutter on polyphase meters and a four-slot shutter on single-phase meters.

FUNCTIONAL

Kilowatthours:

An electronic total kilowatthour register and three programmable time-of-use kilowatthour registers are available. All kilowatthour registers are five-digit continuously cumulative. The three time-of-use rates are mutually exclusive, i.e., only one time-of-use rate is in effect at a time.

Kilowatt Demand:

Kilowatt demand is calculated concurrently with the time-of-use kilowatthours. Demand can be displayed in any (or all) of the following formats: indicating, cumulative, or continuously cumulative. All demand displays are five-digit with the decimal point location programmable for zero, one, two or three decimal digits.

Demand Intervals:

Demand intervals of 15, 30, 60, 120 or 240 minutes, or the full TOU period, are available. However, if the demand interval equals the TOU period, the demand calculation will not be made, and maximum kilowatthours will be displayed in place of demand. Rolling demand may be selected with up to 10 subdivisions per interval as shown in Table 1. The rolling demand measure cannot be used when the full TOU period is selected as the demand interval.

Demand Reset:

Demand reset can be accomplished manually and verified by a continuous "all 8's" display if the meter cover is equipped with a demand reset mechanism. Demand reset can also be accomplished automatically, using the TM-80 programmer or reader thru the communication port. In either case, the demand reset affects all complete past intervals, but not the current interval. The day of last reset (1 thru 366) is recorded for display, if desired.

Demand Delay After Power Outage:

After power outages exceeding a programmable time of 1 to 255 minutes, demand measurement may be delayed by a program-selectable time of 0 to 255 minutes.

Time on Carryover:

Time on battery carryover is measured by the register electronics. The primary use is as a log of cumulative time the battery has been in use. Time on carryover is measured in minutes and has a total capacity of 999999 minutes. For convenience, the time on carryover can be set to zero by the TM-80 programmer whenever a new battery is installed.

Clock:

The register clock maintains time and displays it in a 24-hour format of XX hours and XX minutes.

Calendar:

The register is programmable for a five-year calendar, including leap year. The date is displayed in a day, month, year format of XX days, XX months and XX years.

Daylight Saving Time:

Daylight saving time shifts will occur at 2:00 AM on programmable dates.

Weekday Schedule:

A weekday time-of-use schedule is programmable for each of four seasons. Each weekday schedule can contain up to eight switch points on quarter hours. The eight switch points are shared among the three time-of-use rates and the optional load control switch.

Weekend/Holiday Schedule:

A weekend/holiday schedule is programmable for each of four seasons. Each weekend/holiday schedule can contain up to six switch points on quarter hours. The six switch points are shared among the three time-of-use rates and the optional load control switch.

Day Select:

The register will normally operate on the weekday schedule; however, any day or days of the week may be programmed to operate on the alternate

weekend/holiday schedule. Holidays will always use the weekend/holiday schedule.

Programmable Dates:

A total of 80 dates may be programmed for the five-year program period. Programmable dates include holidays, season change dates and daylight saving dates.

Seasonal Rates:

A total of four seasonal rate schedules is available. Seasonal rate changes occur at midnight of programmable dates. A demand reset occurs at season change, and all kilowatthour and demand registers are copied into last season registers for display.

Program ID:

A two-digit program identification number is stored in the register to identify up to 99 different rate schedule programs. The program ID number can be displayed, if desired.

Meter Code Number:

A nine-digit number can be stored in the register to identify the meter of the specific account. Its use is primarily to identify the meter data when read automatically by a portable reader.

Transformer Factor (TF):

A six-digit number can be stored in the register to specify the TF to a portable reader. The Type TM-80 register is secondary reading and does not apply this TF to the register kWh and kW readings. $TF = CT \text{ ratio} \times VT \text{ ratio}$.

Programming Watthour Constant:

The programming watthour constant K is the number of watthours per register input pulse. The constant K can vary from 0.025 to 999.999. Normally, for a TM-80 register with the standard shutter disk providing one input pulse per meter disk revolution, K is equal to the meter K_h .

TABLE I
ROLLING DEMAND INTERVALS

Interval (in Min.)	Number of Subdivisions									
	1	2	3	4	5	6	7	8	9	10
	Subintervals (in Minutes)									
15	15	X	5	X	3	X	X	X	X	X
30	30	15	10	X	6	5	X	X	X	3
60	60	30	20	15	12	10	X	X	X	6
120	120	60	40	30	24	20	X	15	X	12
240	240	120	80	60	48	40	X	30	X	24

X - Not Available

Display Sequence:

Time and data are displayed on a nine-digit display in the following sequence and format. Items to be displayed each season are programmable and may be omitted from the display sequence.

Display Identifiers:

Each item displayed is uniquely identified with a two-digit identification number, except for the meter code number which takes all nine digits. The first item displayed after the meter code number is identified as 01. The following items displayed will be numbered sequentially as shown in Table 2 (02, 03, etc.). Note that, as items are omitted from the display sequence, the identifier for a specific item may change.

Display Scroll Mode:

The normal display operating mode is continually sequencing through the selected items, each display lasting a program-selectable time of one to 14 seconds.

Display On/Off Times:

Display on and off times are programmable to allow automatically turning off the display during nighttime hours. Display on and off times are programmable on quarter hours and can be different for each of the four seasons.

Manual Display Mode:

By using a magnet rod, a magnetic display switch can be activated through the meter cover to either (1) turn

**TABLE 2
NINE-DIGIT DISPLAY SEQUENCE**

Meter Code Number	X	X	X	X	X	X	X	X	X
Date	0	1		X	X	X	X	X	X
Time	0	2		X	X		X	X	
Time on Carryover	0	3		X	X	X	X	X	*
Total Kilowatthours	0	4			X	X	X	X	X
A Kilowatthours	0	5			X	X	X	X	X
A Kilowatts (indicating)	0	6			X	X	X.	X	X **
A Kilowatts (cumulative)	0	7			X	X	X.	X	X **
A Kilowatts (continuously cumulative)	0	8			X	X	X.	X	X **
B Kilowatthours	0	9			X	X	X	X	X
B Kilowatts (indicating)	1	0			X	X	X.	X	X **
B Kilowatts (cumulative)	1	1			X	X	X.	X	X **
B Kilowatts (continuously cumulative)	1	2			X	X	X.	X	X **
C Kilowatthours	1	3			X	X	X	X	X
C Kilowatts (indicating)	1	4			X	X	X.	X	X **
C Kilowatts (cumulative)	1	5			X	X	X.	X	X **
C Kilowatts (continuously cumulative)	1	6			X	X	X.	X	X **
Total Kilowatthours	1	7			X	X	X	X	X
A Kilowatthours	1	8			X	X	X	X	X
A Kilowatts (indicating)	1	9			X	X	X.	X	X **
A Kilowatts (cumulative)	2	0			X	X	X.	X	X **
A Kilowatts (continuously cumulative)	2	1			X	X	X.	X	X **
B Kilowatthours	2	2			X	X	X	X	X
B Kilowatts (indicating)	2	3			X	X	X.	X	X **
B Kilowatts (cumulative)	2	4			X	X	X.	X	X **
B Kilowatts (continuously cumulative)	2	5			X	X	X.	X	X **
C Kilowatthours	2	6			X	X	X	X	X
C Kilowatts (indicating)	2	7			X	X	X.	X	X **
C Kilowatts (cumulative)	2	8			X	X	X.	X	X **
C Kilowatts (continuously cumulative)	2	9			X	X	X.	X	X **
Programming Watthour Constant (K)	3	0		X	X	X.	X	X	X
Transformer Factor	3	1		X	X	X	X	X	X
Program ID Number	3	2						X	X
Day of Last Reset	3	3					X	X	X

* Leading zeros blanked.

** Demand decimal position is programmable.

on the display during nighttime hours; (2) initialize the display to the first display item; or (3) put the display in the step mode. For display operating procedure, refer to "Display Operation," page 24.

Error Display:

The display is used to indicate fault conditions, should they occur, by a constant error code display. If the magnetic display switch is activated, the display will show one complete cycle and revert back to the constant error display.

Error Codes:

The following error codes will be displayed by the register if the error occurs:

Battery error	Er 000001
Unprogrammed register	Er 000010
RAM error	Er 000100
ROM error	Er 001000

Any combination of the above errors, should they occur, will be displayed together.

Communication Port:

An optical communication port, normally mounted in the meter cover (Fig. 4), provides two-way serial communication between the register and an external programmer or reader. The communication port is used by the TM-80 programmer to (1) initially program the register; (2) reprogram the register; or (3) by a reader to automatically read billing data and perform demand reset. A programmable security code prevents unauthorized access to the register via the communication port.

OPTIONAL FEATURES

Mechanical Register:

The Type TM-80 register can be supplied with a five-dial mechanical register for measuring total kilowatthours. Standard register ratios from 3 17/36 to 333 1/3 are available.

Cover Alternatives:

The standard cover supplied on a meter with a Type TM-80 register is made of LEXAN resin and is equipped with a communication port and a combination battery access port/demand reset mechanism. See Fig. 4. The access port/demand reset mechanism is secured with standard locking or sealing devices. The cover always contains the communication port; however, the following alternatives are also available for battery access and demand reset.

1. A dual key-lock access port/demand reset is available which utilizes one key for battery access and different key for monthly demand reset.

2. A standard demand register reset is available for performing the monthly demand reset. The reset is secured using standard locking or sealing devices. No access is provided for battery changeout through the meter cover. The cover must be removed to change the battery.

3. A key-lock demand reset is available for performing the monthly demand reset. No access is provided for battery changeout through the meter cover.

Load Control Output:

The Type TM-80 register can be provided with a load control switch with single-pole, double-throw, Form C, mercury-wetted contacts. The switch can operate on an independently programmable schedule. This load control switch would normally be used to control an externally mounted contactor capable of switching, for example, a water heater load.

The switch contacts have a maximum rating of 100 VA, 500 volts peak or two amperes peak; however, the arc suppression circuitry provided in the register may limit the application to 120 or 240 volts rms. For proper application, refer to "Application of Outputs," page 29.

Rate Indicator Output:

The Type TM-80 register can be provided with one, two or three optoisolated outputs that can be used to control external lights to indicate the TOU rate in effect. The output associated with the current TOU rate in effect will cause the external light to blink once for each input pulse to the register.

The outputs are semiconductor switches with maximum ratings of 10 volts, dc and three mA, dc. For proper application, refer to "Application of Outputs," page 29.

Increased Resolution:

The Type TM-80 register can be supplied with optics assemblies containing shutter disks with two, four or eight slots. A standard of one input pulse per meter disk revolution is obtained with a two-slot shutter on polyphase meters and a four-slot shutter on Type IRM-70 single-phase meters. A ratio of meter disk revolutions to register input pulses (register R/P) has been defined. Table 3 gives the register R/P for 2-, 4-, and 8-slot shutters used in either single-phase or polyphase meter applications. Increased resolution is obtained using a smaller register R/P (more slots in shutter).

TABLE 3
REGISTER R/P

	For Type IRM-70 Meters	For all Polyphase Meters
2-slot shutter	2/1	1/1*
4-slot shutter	1/1*	1/2
8-slot shutter	1/2	1/4

*Standard shutter configurations.

PHYSICAL DESCRIPTION

The Type TM-80 TOU register is designed for mounting on watthour meters using standard General Electric demand-register mounting posts and connec-

tion lead assemblies. For complete assembly and use on a watthour meter, other necessary components are:

1. The field-replaceable carryover battery installed in its holder (see Fig. 2). The cover photo shows the battery installed.
2. A time-of-use watthour meter cover assembly that includes the programming communication port and cable assembly (see Fig. 4), a battery access port and/or a demand reset mechanism.

TM-80 REGISTER

The register consists of two assemblies: the electronic module and the adapter assembly. They are handled as individual units and easily joined together to form the complete register when assembled on the watthour meter. The adapter assembly is first mounted onto the meter (see Fig. 2), then the electronic module

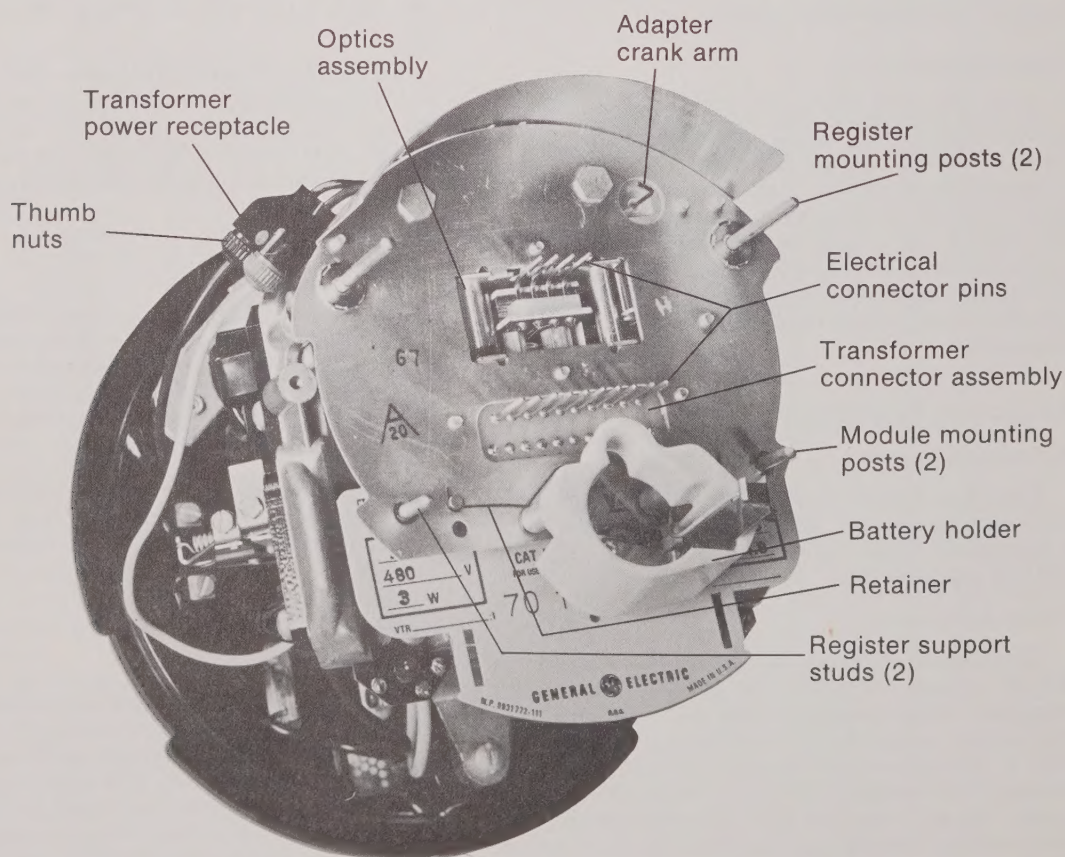


Fig. 2. Type VRM-63-S with TM-80 adapter assembly installed.

is plugged into the adapter and held in position by four mounting screws. See Fig. 3.

The mechanical register is a TM-80 optional feature. It consists of two parts: (1) the mechanical display attached to the upper front of the electronic module (shown removed in Fig. 5) and (2) the ratio assembly attached to the back of the adapter assembly (see Fig. 3). Both are removable, thereby making TM-80 registers available without mechanical displays. This option provides an upper front plate assembled in place of the mechanical display.

Electronic Module

The electronic module consists of (1) three printed circuit boards identified in Fig. 5; (2) the mechanical display; (3) the front plate with digital display bezel; (4) the antiglare window and (5) the meter information nameplates. These all are modularly assembled on the four support posts as shown in Fig. 5.

The nine-digit fluorescent display, visible through the window, is mounted on the display printed-circuit board which is directly behind the front plate. The demand reset lever extends through the front plate (at bottom left). It operates the demand reset switch that is located on the display board.

The logic board, located in the center of the module, contains the register logic, a part of which is the replaceable ROM shown plugged into a socket that is located behind the removable mechanical display. See Fig. 5.

The power supply board, located on the back of the electronic module, contains the load control and rate indicator output options with their associated screw-type (or plug-in) electrical connections. For connection and application information, refer to "Load Control and Rate Indicator Output Options," page 29.

Adapter Assembly

The adapter assembly is modularly constructed with the subassemblies described below, all individually removable and held on by screws. These subassemblies are shown in Figs. 2 and 3.

1. Transformer Connector Assembly -- Two battery holder leads are attached to the front side of the connector board and are removable by unsoldering at the board.

2. Ratio Assembly -- The ratio-assembly drive gear is held in mesh with the register drive gear in the optics assembly by the slot in its upper plate and the brass bushing.

NOTE: The watthour-meter register ratio (R_r) is stamped on the ratio assembly (see Fig. 5). This

is not the R_r for the TM-80 register. For the TM-80:

$$R_r \text{ (TM-80)} = \text{stamped } R_r \times 40/3$$

3. Optics Assembly -- It contains the optics pickup assembly and is removable through the front of the adapter plate without removing the optics assembly.

4. Battery Holder -- This is held to the adapter plate by two mounting posts. These posts also hold the retainer (see Fig. 2) that locks the adapter assembly to the register support studs.

Carryover Battery

The TM-80 register uses a nonrechargeable, six-volt primary battery with electrical contact areas at both ends. The negative cap end is magnetic and can be held by the magnet rod for replacement through the meter cover.

TOU METER COVER ASSEMBLY

The cover assembly consists of a conventional meter cover made of LEXAN resin, which is adapted for TM-80 time-of-use application with the following additions:

1. Communication Port -- This port includes the two optical components visible from the front. These, in turn, communicate with similar components contained within the programmer probe when it is magnetically attached to the communication port. The connector on the cable plugs into the three-pin connector located on the electronic module. See Fig. 6.

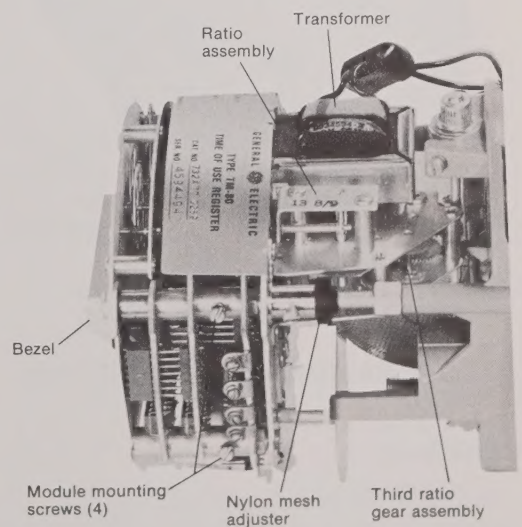


Fig. 3. TM-80 register installed on Type IRM-70 meter (right view).

2. Access Port and/or Demand Reset Assembly -- These assemblies (shown in Fig. 4) perform the following functions:

- a. Permits access for battery replacement. The latch is released by lifting the lever and rotating it clockwise; this allows the hinged hatch to open. The same access port with a key-lock latching and reset mechanism is available. Rotation of the access key clockwise in the lock permits opening the hatch.
- b. Allows the reset of maximum demand by rotating the lever or key-lock assembly counterclockwise until the reset paddle inside the cover deflects the reset switch arm on the face of the register.

Both the manual-lever-type and lock-type demand resets are available on TOU cover assemblies without the access port. Demand reset is performed in both by the same counterclockwise rotation.

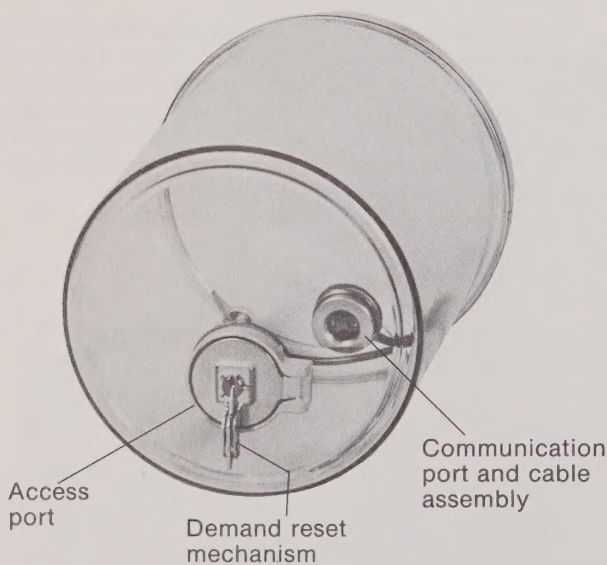


Fig. 4. Cover assembly.

OPERATIONAL DESCRIPTION

GENERAL

The Type TM-80 register is a microprocessor-based computer system programmed to perform the time-of-use metering function. The computer system consists of a CMOS microprocessor, ROM memory, RAM memory and the associated input and output circuits.

The most significant of the associated circuits is the display circuit which consists of a second microcomputer programmed to do the display functions.

Figure 7 shows a simple block diagram of the TM-80 register. The heart of the TM-80 is the main computer which consists of the CPU (Central Processing Unit), ROM Memory (contains program steps) and RAM Memory (for storage of data). There are several inputs to the main computer. The first of these is 60 Hz, which is a logic-level input signal derived from the ac line and is used as the primary time base for the clock and calendar functions. Second is the output from a crystal oscillator, which is the secondary time base and is used only during a power outage. Next are the input pulses which come from the optics assembly and are proportional to the meter disk revolutions. Next are two switch inputs: (1) the monthly reset switch, used for manual reset of demand at the time of meter reading and (2) the display switch which, when magnetically activated, initiates various display operating modes.

Outputs from the main computer are sent to the display computer, load control switch and rate indicator outputs. The outputs to the display computer are messages containing data and instructions telling the display computer what to do with the data. The outputs from the display computer, in turn, directly drive the nine-digit, seven-segment display. The output from the main computer to the load control switch simply either energizes or de-energizes the coil of the load control relay. The three-rate indicator outputs are optically coupled isolators which are either energized or de-energized by the main computer.

The interface from the main computer to external equipment (such as a programmer or a reader) is the communication port. The communication port is a two-way optically coupled data communications path. Physically, the communication port is normally mounted in the meter cover, while the mating part, attached to a programmer or reader, is coupled to it during the time it is desired to communicate with the main computer of the TM-80 register.

Last to be described are the necessary power supply circuits, which take energy from the ac line and supply power to the main computer and all the input/output circuits mentioned above. An alternate battery supply is used to support only the main computer to maintain memory and keep time during power outages.

OPERATIONAL

When the TM-80 register is initially installed and energized, it is in the unprogrammed mode and performs only minimum functions, which are described later. Normally, the next step would be to program the register via the communication port, using a programmer that is compatible to the TM-80 register.

The programmer must first input a security code to the main computer, one bit at a time, synchronized with clock pulses generated by the main computer. At this time the communication rate is very slow. The main computer is generating clock pulses at the rate of 60 per second, based on the 60 Hz input.

When the main computer receives the proper security code (it is the same for all unprogrammed TM-80 registers), it acknowledges this to the programmer and awaits the next command from the programmer. The next command would be to load the time-of-use schedules, programmable dates, demand interval lengths, date, time, etc., into the RAM memory. Also loaded into memory at this time is a new security code which must be used by a programmer or reader for any subsequent access to the main computer of the TM-80. The transfer of the relatively large amount of data to program the register occurs at a much higher data rate than 60 Hz, but is still under the control of the main computer in the TM-80. The data rate is actually dynamically variable, depending on what higher priority tasks the main computer needs to do. The programming and verification takes only seconds to complete.

After programming, the main computer knows the date and time and the schedule of functions it must perform. The most important functions are to keep time and count input pulses generated from the meter disk. This is accomplished by the 60 Hz input interrupting the main computer, causing it to recognize that another 1/60th of a second has passed. Also, at each 60 Hz interrupt, all inputs are checked to see if another input pulse has occurred, whether the monthly reset or display switch is closed or if a proper security code has been received via the communication port.

When 3600 interrupts have occurred, one minute has passed and the clock time is updated and available for display. On each quarter hour the TOU schedule is checked to determine if a TOU rate change should occur or if a load control action should occur. Also checked on each quarter hour are the display on and off

times to determine if the display should be turned off for the nighttime hours or turned on for normal daytime operation. For every four quarter hours that have passed, the hour is updated for display. The time display is 00 thru 23 hours and 00 thru 59 minutes, with 00 hours and 00 minutes being midnight.

For every 24 hours that pass, the day must change. When the day changes, it is checked to determine if it was the last day of the month and, if required, change the date to the first day of the following month. The date is displayed in a six-digit format of day, month and

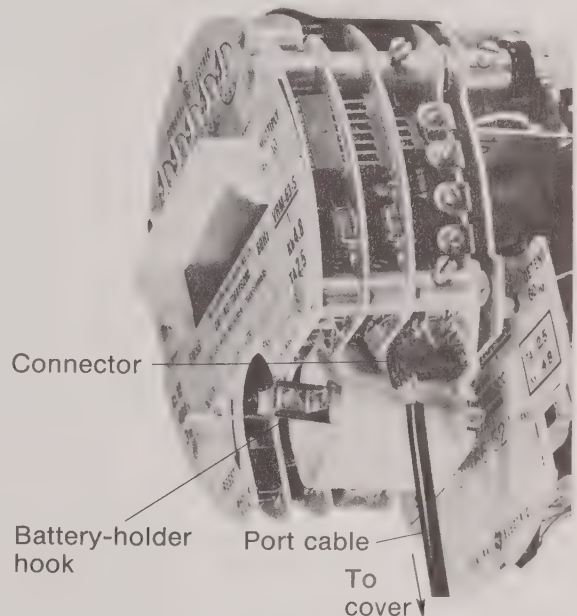


Fig. 6. Meter with communication port cable and connector installed.

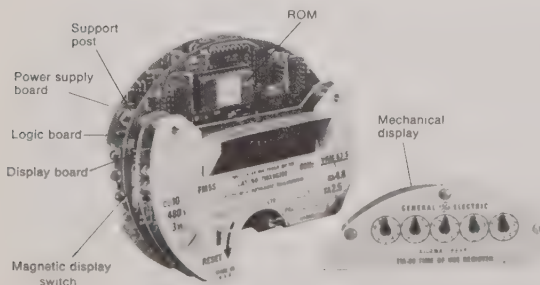


Fig. 5. TM-80 register module with mechanical display removed.

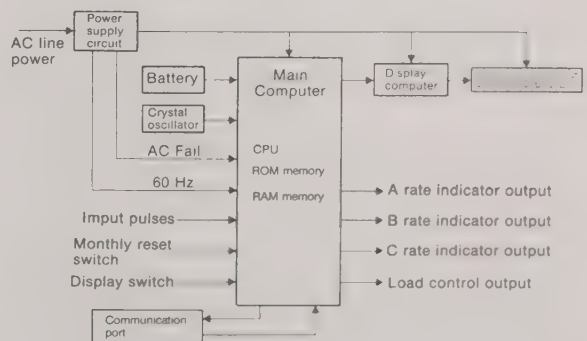


Fig. 7. Simple block diagram of the TM-80 register.

year where days are 01 thru 31, months are 01 thru 12 and years are 00 thru 99. The last day of the month is determined from a table stored in the ROM memory. February 29 is added every four years, set to occur on leap year.

Every time a day changes, the table of programmable dates is checked to determine if a season schedule change is to occur, if it is a holiday or if a daylight saving change is to occur on this day. If a season change occurred, a demand reset is automatically performed at midnight (00 hours, 00 minutes) of the season change date, and all kilowatthour and demand counters are copied into last season registers and are available to be displayed. Additionally, TOU schedules and display on/off times can change for the new season, and the new schedules are checked to determine the TOU rate in effect and the load control switch state. If the new day is a holiday, the weekend/holiday schedule is checked to determine the rate in effect and load control switch state. If the new day is a daylight saving change date, it is known at midnight when the table of programmable dates is checked, but does not occur until 2:00 AM. Because of this, if a daylight saving shift is to occur, it must be programmed prior to midnight of the programmable date. The spring daylight saving time shift causes the clock to advance to 3:00 AM at the 2:00 AM time of change. The fall shift causes the clock to shift back to 1:00 AM at the change.

One additional change that can occur on a new day is a change to the alternate weekend/holiday schedule. Actually, any day or days of the week can be programmed to operate on the alternate weekend/holiday schedule.

Year changes occur at midnight (00 hours, 00 minutes) as of January 1. Years contain 365 days except leap years which have 366.

Pulses which are input to the main computer from the optics assembly are sampled on every 60 Hz interrupt to the main computer. All input pulses are accumulated in a total kilowatthour register. Additionally, pulses are accumulated in an A, B or C kilowatthour register, depending on the time-of-use schedule, and calculated demand is input into an associated A, B or C demand register. A, B or C rate indicator output provides an output pulse. If no time-of-use rate is in effect, total kilowatthour pulses only are accumulated, and no output pulses appear on the rate indicator outputs. For more detailed information, refer to "Input Pulses and Rate Indicator Outputs," page 14.

All kilowatthours (total, A, B and C) and all demands are accumulated and stored in RAM memory as pulses. When these are to be displayed, the main computer sends the data (number of pulses), the K (watthours per pulse) and a code identifying the type of data to the display computer. The display computer then multi-

plies the number of pulses by K and displays the result on a nine-digit display in the proper format. The display computer assigns the identifier number, which is displayed in the front of each reading, places the decimal point in the demand displays, and times the duration each display item is displayed.

The items to be displayed for each season, the duration of each display, decimal point position and the K value are all contained in the program which was loaded into RAM memory from the programmer. The main computer transfers this information to the display computer each time a new display sequence is initiated. The display identifier counter in the display computer is also reset each time a new display sequence is initiated. With the exception of the meter code number, which requires all nine digits for display, the display identifiers are sequentially assigned to the items to be displayed. Identifiers begin with 01 for the first item to be displayed after the meter code number and continue thru a maximum of 33 when all items are selected for display. Depending upon the items to be displayed each season, it is possible that an item might have a different identifier in a new-season display sequence.

It should be noted that the items selected for display are independent of the time-of-use kilowatthour pulse accumulation and demand calculations. If the TOU schedule calls for C rate, C rate kilowatthour pulses are accumulated, and both indicating and cumulative demand are calculated even though none, one or all are selected for display. Likewise, at season change, all kilowatthour registers and demand registers are copied into last season registers. The last season registers may or may not be selected for display. These readings, whether displayed or not, may be obtained by a TM-80 programmer or a reader capable of reading the register via the communication port. The readings, if not displayed in the present program, may also be obtained by reprogramming the register with a similar program which has the desired items selected for display.

OPERATION IN THE UNPROGRAMMED MODE

In the unprogrammed mode the TM-80 register will keep time and accumulate total kilowatthour pulses. The time starts at 00 hours and 00 minutes at the time the register is energized. The elapsed time since the register was energized is maintained in hours and minutes until 24 hours have passed. When 24 hours have passed, the date display is advanced to day 02. The date display is a six-digit day, month and year format beginning at day 01, month 01 and year 00. The minutes, hours, days, months and even years will continue to accumulate if the register is left in the unprogrammed state.

Total kilowatthour pulses will accumulate from the time the register was energized and can be displayed. The unprogrammed register uses a K value of 0.3 watt-hour per pulse for display purposes. It should be noted that these pulses remain in the total kilowatthour register even after the register is programmed; however, they will be displayed using the newly programmed K value.

The display will normally be blank in the unprogrammed mode, but will respond to the magnetically activated display in the normal manner (refer to "Display Operation," page 24). The display sequence for the unprogrammed mode is shown below.

Meter Code Number	0 0 0 0 0 0 0 0 0
Date (Day-Month-Year)	0 1 0 1 0 1 0 0
Time (Hours-Minutes)	0 2 0 0 0 0
Time on Carryover (Mins.)	0 3 0
Total kWh	0 4 0 0 0 0 0
Error Display	E r 0 0 0 0 1 0

When the display sequence is initiated with a magnet, the display will scroll thru the above sequence, showing each item approximately seven seconds. The display will freeze on the error display Er 000010, the 1 in the second position indicating that the register is unprogrammed. The error display will remain for approximately five minutes, then the display reverts back to a blank display.

The error display shown above indicates that a battery is in place. With the battery in place, the register will maintain time and retain data thru a power outage. Time on carryover will accumulate and indicate the cumulative number of minutes the register has been without power. If a battery was not installed, the error display would be Er 000011.

PROGRAMMING OPERATION

Whether initially programming or reprogramming a TM-80 register, the most important thing to remember is the proper security code, which is the first thing the main computer must see. For unprogrammed registers, ID number 00 must be selected for PRESENT ID in the programmer. If this is not done, the proper security code will not be presented to the main computer, and the response back on the programmer display will be TRANSMISSION ERRORS. Likewise, when attempting to reprogram a register which already contains a program, the PRESENT ID selected in the programmer must be the same as the program ID number contained in the register.

If the communication path between the programmer and register is faulty or if the register is not powered or

not operating properly, the expected response on the programmer display would be METER NOT RESPONDING.

After the main computer of the register receives the proper security code and responds back to the programmer, it then awaits the command to load the new program into RAM memory. After the new program is loaded, it is read back to the programmer to confirm that it was properly loaded and the RAM memory properly remembers it. When this is successfully accomplished, the programmer displays FINISHED PROGRAMMING. If it fails, the programmer displays PROGRAM NOT VERIFIED. In this case, the register error display should also show an Er 000100, indicating a RAM error.

When finished programming, the register switches to the new schedule on the next minute change after the programming is complete. If the display was displaying an error display, it must be cleared by either using a magnet to initiate a new display sequence or by a demand reset. When programming a register, no kilowatthour or demand data is modified because it is retained in the form of input pulses. However, data can be displayed as different values by changing the K programmed in the register.

NOTE: Should the wrong K values be used, the wrong values will be displayed.

TOU SCHEDULES

There are two types of daily time-of-use schedules which can be programmed in the TM-80 register. The first is the weekday schedule which can contain up to eight switch points. The switch points can be set to any quarter hour of the day. On any switch point the TOU rate can be changed and one load control state can be changed. For example, at 1315 the A rate can begin and the load control switch can be de-energized -- using only one of the eight switch points. It is also possible to have no TOU rate in effect. There is a different weekday schedule for each of four seasons. The appropriate weekday schedule for the current season is used each day unless the current day is a programmed holiday or programmed to be a weekend day (not restricted to Saturday and/or Sunday).

The second time-of-use schedule is the weekend/holiday schedule. It can contain up to six switch points, which operate in the same manner as the switch points of the weekday schedule. The weekend/holiday schedule is used on days programmed into the table of programmable dates. It is also used on any day or days of the week defined as weekend days. These repeat on a seven-day cycle. If Monday, Wednesday and Friday were defined as weekend days, then the register would operate on the weekend/holiday schedule each and every Monday, Wednesday and

Friday and would operate on the weekday schedule every Tuesday, Thursday, Saturday and Sunday unless a particular Thursday, for example, is programmed as a holiday.

PROGRAMMABLE DATES

There is capacity for up to 80 programmable dates in the TM-80 RAM memory. The dates are used to define a season change, a holiday or a daylight saving change date. Combinations of these can occur on the same date; however, they will require use of more than one of 80 dates. For example, if both a season change and a holiday were to occur on July 4, two entries of July 4 would be required in the table. The first of these would cause a season change and the second would define the day as being a holiday.

The 80 dates can be used in any manner throughout the five-year program capacity of the register. However, there must be at least one entry in the table for each year, and the first date of the year must be earlier than the last date of the previous year. The main computer of the TM-80 register uses this table to determine if the year has changed. This is all taken care of when the user PROM for the programmer is generated. It is done without affecting the desired schedules by, for example, inserting holidays on weekend days, etc.

INPUT PULSES AND RATE INDICATOR OUTPUTS

When the optics assembly shutter rotates, as gear-driven by the watthour meter disk shaft, photosensors A and B are sequentially turned on, then off, by the slots in the shutter. These slots move across light paths produced by two LEDs, each LED aimed at its respective photosensor. The arrangement of the optics assembly shutter and the two photosensors is shown in Fig. 8, whereas Fig. 9 shows the output from the photosensors as the shutter rotates.

The electronics module accepts and stores pulses from the optics assembly as they are produced. One pulse consists of four state changes produced in the following sequence (this is illustrated in Fig. 9).

State	Photosensor	
	A	B
1	1	0
2	0	0
3	0	1
4	1	1

With the watthour meter disk running in the forward direction, one pulse is added to the electronic module counter when state 4 changes to state 1 after states 1

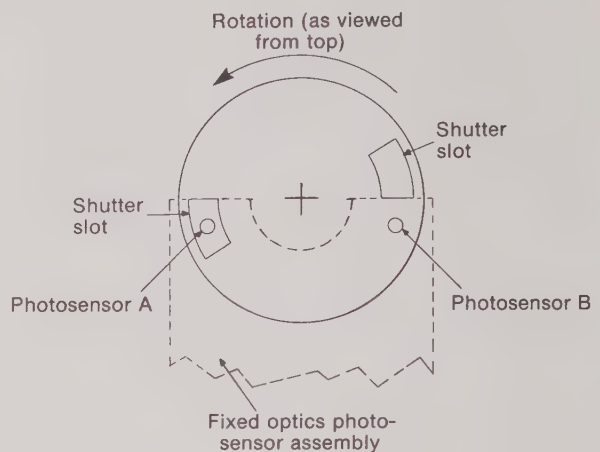


Fig. 8. Arrangements of optics assembly shutter and photosensors.

through 4 have been produced. Pulse accumulation will also occur with the watthour meter disk rotating in the reverse rotation. In this case, a pulse will be added when the state change from 0-0 to 1-0 occurs after the four preceding states have been produced in the reverse order.

Figure 8 shows the optics assembly in state 1. As can be seen, it takes 1/2 a revolution of the two-slot shutter to produce the four states. Two-, four-, and eight-slot shutters are available in TM-80 optic assemblies. The four-slot shutter requires 1/4 revolution to produce the four states and the eight-slot shutter 1/8 revolution. This variety of shutter slot options provides for the three different pulse output resolutions available. The single-phase watthour meter normally uses four slots to produce one pulse per meter disk revolution because the shutter turns 1/4 of a revolution for each revolution of the General Electric meter disk shaft, whereas the polyphase meter uses a two-slot shutter because it turns 1/2 revolution for each revolution of the GE meter disk shaft.

Rate indicator switches A, B and C perform two functions. One is to provide a switch closure that can be used with an external light source to indicate which rate schedule is being used at the time. The second is to provide an indication as to the rate of usage. This is done by blinking the external light source at a rate proportional to energy usage. The rate indicator switch is closed, then opened, once per pulse. It alternates on, then off, every two changes in state, always being turned on when a pulse is added to the pulse counter.

KILOWATTHOUR ACCUMULATION

As previously described, kilowatthours are accumulated and stored as pulses. The total kilowatthour register accumulates all input pulses to the register, whether it is programmed or not. Based on the time-of-use schedule, A, B or C kilowatthour pulses are also accumulated. Only one time-of-use rate can be in effect at a time. If either A, B or C rate is in effect for 24 hours of each day, the total of A, B and C kilowatthours should equal the total kilowatthours, with several possible exceptions. First, it is possible that some pulses were accumulated in the total kilowatthour register between the time it was energized and later programmed. This would result in total kilowatthours being greater than the sum of A plus B plus C kilowatthours. Another possible condition which could result in total kilowatthours being displayed as much as two kilowatthours more than the sum of A, B and C is inherent in a digital display. Because the display of kilowatthours is truncated (fractional parts of kilowatthours are not shown), the sum of the fractional parts of A, B and C kilowatthours could add up to nearly three kilowatthours, which would be shown in total kilowatthours.

This truncation does not contribute to any kind of cumulative error because the actual number of pulses are maintained in memory and, when enough pulses are accumulated for a whole kilowatthour, it then shows the next time the display calculation is made.

Another condition which can occur which has the appearance of the sum of A, B and C kilowatthours being greater than the total kilowatthours (an impossible condition) results from the time required to read all the display items. If, at the time of reading, C rate is in effect and C kilowatthours is item number 13 to be displayed, nearly a minute of time could pass between the total kilowatthour display and C kilowatthour display. During this time it is possible for sufficient pulses to occur to advance the C kilowatthour reading. This is a highly unlikely occurrence, but could happen in some applications.

At a season change, all the kilowatthour registers and demand registers are copied into last season registers. What actually gets copied is the number of pulses in, for example, the total kilowatthour register at midnight (00 hours, 00 minutes) of the season change date. The current-season total kilowatthour pulses simply continue to accumulate. The last season registers contain, most simply, a "snapshot" of the current-season kilowatthour registers at the time of season change. The season change has no effect on the current-season kilowatthour registers. The last season registers are changed only at the time of the next season change, when all last-season register contents are replaced by the new "snapshot."

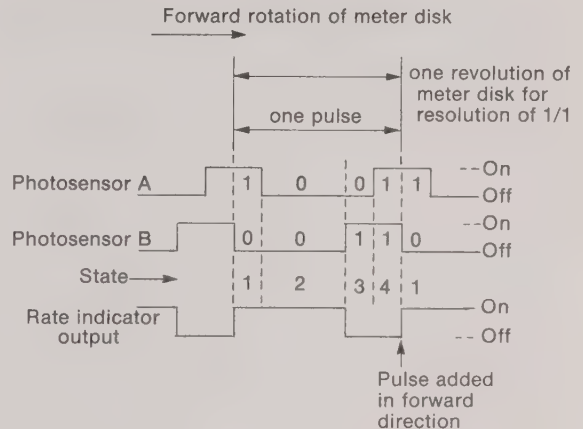


Fig. 9. Output from optics assembly photosensors as the shutter rotates.

All kilowatthour displays are five-decimal digits capable of displaying 00000 thru 99999. The actual data accumulation is a binary count of the pulses. Each pulse is worth K watthours. To get the proper rollover from 99999 to 00000, the programmer provides a binary quantity equal to 100,000,000 divided by K. When any kilowatthour register pulse count reaches this number, it is reset to zero to get the five-digit rollover.

It is possible to reprogram a register with a different K to obtain different kilowatthour and demand readings. If this is done, all readings will be proper unless a five-digit rollover has occurred. The rollover from 99999 to 00000 causes the pulse count to be reset to zero, which will result in an error that cannot be corrected. If a register was programmed with an incorrect K value and it is certain that a five-digit rollover did not occur, it is acceptable to reprogram the register with the correct K value to get the proper readings.

Kilowatthour register pulse counts can only be set to zero by completely de-energizing the register by removing both ac power and the battery. Because of the low power drain of the register, it may take several seconds to completely discharge all interval capacitances, so power and battery must be removed for at least several seconds.

ROLLING DEMAND OPERATION

Demand is calculated as kilowatthours divided by the interval time (in hours) to get the average kilowatt demand for the interval. The calculation is actually done on pulses and the result stored as pulses, which are multiplied by K for display. The result is displayed as five-decimal digits with 0, 1, 2 or 3 digits to the right of the decimal point. The decimal point position is selectable from the keypad on the TM-80 programmer.

The demand interval length is contained in the programmer user PROM. Both of these items are loaded into the TM-80 RAM memory via the communication port.

Demand can be displayed as indicating demand, which gets reset to zero at monthly demand resets; as cumulative demand, which adds the past month's demand to the cumulative total of all past demands at the time of demand reset; or as continuously cumulative demand, which is simply the sum of indicating and cumulative demands at any point in time. Continuously cumulative demand is not actually stored in memory, but is calculated as the sum of indicating and cumulative demand at the time of display. Both indicating and cumulative demands are always calculated for each time-of-use rate. Any or all (or none) of the demand formats can be selected for display.

For the calculation of rolling demand, the block interval demand can be divided into a maximum of ten subintervals. The only restriction is that the subinterval length must be an integral number of minutes and the number of subintervals times the length of the subinterval must equal the desired interval length. For example, a 15-minute demand interval can be divided into three subintervals of five minutes each.

Using the above example of three five-minute subintervals, the calculation of demand will be described. At the end of each subinterval the sum of the pulses for the past three subintervals is calculated. This sum is then multiplied by four (the result of dividing by the 1/4-hour demand interval length). This result is the average demand for the past 15 minutes. It is then compared to the maximum demand last attained for the current TOU rate and, if greater, will become the new maximum demand. Five minutes later, at the end of the next subinterval, the demand is again calculated using the last three subintervals. If the new result is greater than the maximum, it will become the new maximum demand.

It should be noted from the above example that demand is calculated only at the end of the interval, and an interval can end at the end of any subinterval (every five minutes in the above example).

Demand intervals are normally synchronized to real clock time, since all TOU periods begin on quarter hours and all demand intervals are multiples of quarter hours. It is possible to be out of synchronization after programming or following a demand delay after a power outage. At the next TOU rate change, resynchronization will occur.

DEMAND RESET

The reset of demand in the TM-80 register is initiated either manually, using the reset mechanism in the meter cover, or automatically at season change. Demand

reset can also be initiated via the communication port by a TM-80 programmer or a reader. Demand reset via the communication port results in the same actions as manual reset.

In manual reset, the switch closure is recognized by the main computer on the 60 Hz interrupt. The main computer then resets all maximum demands and also sends a message to the display computer to display all 8's on the digital display for feedback to the operation, indicating the reset has been accomplished. Also stored in RAM memory at the time of reset and selectable for display is the day (1 thru 366) of last reset.

The demand reset of indicating demand causes the A, B and C maximum indicating demands to be set to zero. The reset of cumulative demand causes the maximum demand attained since last reset to be set to zero and adds this month's maximum demand to the cumulative total of all past demands. The cumulative total is the cumulative demand measure which is available for display. Continuously cumulative demand is the sum of indicating and cumulative demands and, immediately after reset, is numerically equal to cumulative demand. It should be noted that demand reset affects only the maximum demand and all completed intervals. It does not affect the current subinterval being measured.

An automatic demand reset occurs at midnight (00 hours, 00 minutes) of a season change date. The maximum indicating and cumulative demands for each TOU rate are stored in last season registers, just prior to the reset action. The demands in the current season registers are stored just after reset. Immediately after the season change reset, all current-season indicating demands will read zero, and all cumulative demands will have the maximum demand which occurred between the last reset and the season change added to the cumulative total. Continuously cumulative demand for both last season and current season is still the sum of the respective indicating and cumulative demands. The automatic reset at season change does not affect the day of last reset.

POWER OUTAGE OPERATION

When a power outage (loss of ac voltage to the TM-80 power supply transformer) is detected by the power supply circuit, the battery supply is switched on and the ac fail signal is sent to the main computer. The ac fail signal interrupts the main computer. The main computer then recognizes the ac fail condition and enters a power down routine. In the power down routine all data is stored in RAM memory except the items required by the CPU to maintain time. In the power down routine the clock to the CPU of the main computer is switched to the 1024 Hz clock signal from the crystal oscillator/divider. This 1024 Hz clock signal is used as the secondary time base for timekeeping.

The main computer is now operating at an extremely low clock rate to conserve battery power. The only function the main computer is doing is keeping track of the number of minutes which have passed. No input pulses are counted and nothing is displayed -- only the essential circuits of the main computer are powered by the battery.

When ac power is restored, the main computer switches back to its normal high-speed clock and again uses the 60 Hz input for the time base. The main computer must now bring the clock and calendar up to date, since only minutes were counted during the power outage. In a very rapid manner the minutes are added to the clock time, and all the checks of TOU schedules, programmable dates, etc., are done in the same manner as in real time operation. Demand calculations and display functions are not done during this "catch up" time. When all the minutes accumulated during the power outage are added to the register clock, the main computer is "caught up" to the current time. At this point in time the TOU rate is proper, the season is correct, etc. The load control switch, however, will not be energized, if scheduled, until the next minute change after "catch up".

The "catch up" takes approximately one-half second per hour of outage. After a two-day outage, for example, the register could take as long as about 24 seconds to "catch up". During this time the register will appear to be doing nothing -- no display, will not respond to demand reset or display switch, and will not respond to the programmer. The register does count 60 Hz pulses and input pulses from the meter disk during the "catch up" time.

Normally the "catch up" time would be of little concern and hardly ever observed. The most likely time it would be observed is at the time of initial meter installation in the field after the register was programmed in the meter shop several days earlier. The meter installer should be advised to wait an appropriate length of time after installation to view the register display.

The number of minutes the register was on battery carryover is added to the cumulative total of time on carryover and is selectable for display. The time on carryover is maintained to aid in replacing the battery when its expected useful capacity is expended. The time on carryover can be set to zero with the TM-80 programmer at the time a new battery is installed. Zeroing the time on carryover at the time a new battery is installed is a convenient means of monitoring the life of each battery in service.

An additional function of the TM-80 register which relates to power outage operation is the delay in demand measurement following a power outage. This function is programmable to suspend the measurement of demand for a programmable number of min-

utes following a power outage exceeding a second programmable number of minutes. This function could be programmed to suspend demand measurement for ten minutes following each power outage exceeding one hour. The ranges of programmability are listed under "Specifications", page 3.

SELF-CHECKING AND ERROR DISPLAY

There are three self-checking routines which the main computer of the TM-80 register runs which could result in error displays, in addition to the Er 000010 display indicating an unprogrammed register. Below is a table of the possible error displays.

DESCRIPTION OF ERROR	DISPLAY
Battery error	Er 000001
Unprogrammed register	Er 000010
RAM error	Er 000100
ROM error	Er 001000

A battery error will result if the battery voltage drops below 4.5 volts when an approximate two-milliampere load is applied. This battery test is performed automatically each midnight or is manually initiated each time the display switch is magnetically activated. To perform the test, the main computer outputs a signal to turn on a transistor switch which applies the two-milliampere load and inputs a voltage proportional to the battery voltage to a comparator circuit. The comparator output indicates either a pass or a fail condition, which is input back to the main computer. If a fail condition results, the main computer sends the error message to the display computer at the end of the normal display cycle. The display then locks on the Er 000001 message. If the faulty battery is replaced, the next time the battery test is performed (and passes), the error message will be cleared and display will return to its normal scroll mode.

A RAM error message is the indication of a checksum failure on the data loaded into RAM memory from the programmer. Most of this data consists of the week-day and weekend/holiday schedules, display tables and the table of programmable dates. A register showing a RAM error message will also cause a PROGRAM NOT VERIFIED result if checked with the programmer.

A ROM error message indicates a checksum failure of the ROM memory contents. The checksum failure of either the RAM or ROM memory contents indicates that one or more bits stored in the memory are different from what they should be. These erroneous bits could cause an operational failure of the register, resulting in erroneous billing or improper load control operation. For these reasons, if a ROM or RAM error is

detected, the register enters a fail-safe operating mode. In the fail-safe operating mode, all data is retained, time and date continue to advance and total kilowatt-hour pulses are accumulated. No A, B or C kilowatt-hours are accumulated, no demand is calculated and the load control switch remains de-energized. It is possible the erroneous bits could affect the fail-safe operation, causing complete failure of the register; however, to the best of its ability it will retain billing data and continue to accumulate total kilowatt-hour pulses.

The register display shows an error message continuously during the programmed time for the display to be lighted. If it is desired to read the data from the register, the display switch must be activated with a magnet. The display will then scroll thru one cycle and revert back to the continuous error display. The other operating modes of the display will also function, but will always end up with the continuous error message.

If multiple errors occur, the error message will contain two (or more) 1's. If an unprogrammed register is energized without a battery installed and with the display switch activated (thus initiating a battery test) to view the display, the resulting error message will be Er 000011. All other combinations of error messages are possible, should multiple fault conditions occur.

REMOVING THE REGISTER FROM WATTHOUR METER

The procedure for removing the Type TM-80 TOU register from a watthour meter is as follows:

1. Make sure that the meter is de-energized, then loosen the cover and raise it from the meter until the communication port cable assembly (see Fig. 6) can be disconnected from the register. Disconnect the cable assembly and remove the cover.

2. Remove the battery, then disconnect the power leads from the register by unscrewing the red and black thumb nuts.

3. The complete register is most easily removed from the meter in two parts because the adapter assembly (see Fig. 2) is secured to the meter by the register support studs and the retainer. Therefore, first remove the electronic module, which is the front section, as follows:

- a. Loosen the four module mounting screws (two on each side) shown in Fig. 10. Do not loosen the two screws that are behind the adapter plate; these hold the adapter assembly to the meter.
- b. Grip the module evenly on each side, then pull it away from the adapter assembly. Place the module faceup on a clean, flat surface.

4. On the adapter assembly is a retainer, shown in Fig. 2. It is a piece of formed wire held to the adapter plate by the battery-holder mounting screws. The retainer is hooked into slots in the register support studs, which extend through two holes in the adapter plate. Pull the ends of the retainer down and out of the slots in the support studs.

5. Loosen the two adapter mounting screws and slide the adapter assembly off the register mounting posts.

6. To prevent damage to the TM-80 register, it should be stored on a packing bracket. When so doing, first slide the adapter assembly onto the bracket mounting posts, then slide the module on, being careful to align the electrical connections properly. Tighten all six mounting screws.

INSTALLING THE REGISTER ON A WATTHOUR METER

The section entitled "Meter Types" on page 3 lists the watthour meter types that will accept the Type TM-80 TOU register.

For meters that are manufactured to accept the TM-80 register (Type IRM-70, VRM, etc.), complete the steps listed below.

1. Remove the Type TM-80 register from its packing bracket (Fig. 10).
- a. First loosen the four electronic module mounting screws (two on each side) shown in Fig. 10. Grip the module evenly on each side, then pull it away from the adapter assembly and packing bracket. Place the module faceup on a clean, flat surface.

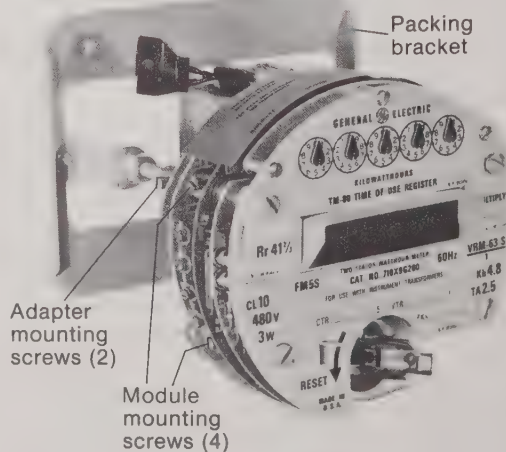


Fig. 10. Type TM-80 TOU register.

- b. Loosen the two adapter mounting screws and slide the adapter assembly off the packing bracket posts.

2. Assemble the TM-80 adapter assembly to the register mounting posts.

- a. First slip the adapter assembly onto the register mounting posts and carefully slide inward until the adapter posts rest against the nylon mesh adjusters (see Figs. 3, 11 and 12) and the register support studs extend through the adapter plate.

CAUTION: WHEN SLIDING THE ADAPTER ASSEMBLY INTO PLACE, CARE SHOULD BE TAKEN NOT TO DAMAGE THE NYLON REGISTER DRIVE GEAR OR THE PINION ON THE ROTOR SHAFT. IF IT APPEARS THAT THE NYLON GEAR WILL BOTTOM OUT ON THE ROTOR PINION BEFORE THE ADAPTER POSTS SEAT, BACK OFF THE MESH ADJUSTERS EVENLY TO PREVENT THIS.

- b. Hook both ends of the retainer over the register support studs that extend through the adapter plate. This is shown in Fig. 2.
- c. Electrically connect the TM-80 by screwing the thumb nuts into the transformer power receptacle. Assure correct polarity by assembling the red thumb nut into the red dot side of the receptacle. Tighten both nuts firmly.

3. Adjust the mesh between the nylon register drive gear and the meter rotor pinion. Refer to Figs. 11 and 12.

- a. Turn the mesh adjusters on the mounting post so that the register drive gear just tops when the adapter assembly is held firmly against the mesh adjusters. Both adjusters should be evenly spaced from the nuts on the register mounting posts.
- b. Check topping condition by moving the third ratio gear (see Fig. 3) in the ratio assembly back and forth with your finger until you feel the teeth just touch. On polyphase meters this gear is less accessible, so use a small tool, such as a soft plastic rod. The drive gearing should be in its normal operating position when the check is made. On adapter assemblies with no ratio gearing, move the nylon drive gear with your finger. This gear is more easily accessible from the right side of the meter.

- c. Be sure that both of the adapter mounting screws are loose. Turn both mesh adjusters

clockwise between 2 and 2-1/4 notches to obtain the recommended mesh of approximately 1/2 the depth of gear teeth.

- d. Press the adapter assembly firmly against the mesh adjusters and tighten the mounting screws.
- e. Move either the third ratio gear or nylon drive gear with your finger to ensure there is some drive gear backlash, yet ample engagement between the drive gear and the rotor pinion.

4. Assemble the TM-80 electronic module to the adapter assembly. Refer to Figs. 2 and 3.

- a. Grip the module evenly on each side and slide it onto the register mounting posts, then carefully slide inward. Make sure that the two rows of electrical connector pins enter their appropriate holes on the module printed circuit board. Be sure that the module mounting posts on the adapter enter the module's lower post holes.
- b. Press the electronic module firmly and evenly inward until the module bottoms against the adapter assembly.

NOTE: Be sure that the mechanical register drive coupler and the adapter crank arm (see Fig. 2) engage without topping or binding. When bottomed, there should be no space between the module posts, adapter posts, and "E" ring surfaces.

- c. Press down over each of the four mounting posts and tighten the mounting screws firmly. (See Fig. 10).

5. If necessary, assemble the lower register nameplate.

- a. Loosen the two lower screws on the register front plate.
- b. Assemble the nameplate by inserting the slots under the screw heads, then hold the nameplate in position and tighten the screws firmly.

6. Calibrate the watthour meter. Calibration of the meter should be checked after the TM-80 register is installed, even though the register is a low-friction device. If for no other reason, it is an excellent way to check the mesh between the nylon register drive gear and the pinion on the rotor shaft. Slow or erratic readings indicate a deep mesh. Calibrate the meter in the normal manner with the register energized at the rated voltage. A battery need not be installed at this time, but must be before the meter is put into service.

As described in Step 2-c, correct polarity must be observed when the power leads are connected. See Fig. 2. Thus, in the event the register transformer primary should open, the meter will tend to slow down slightly rather than run faster.

- a. Apply rated voltage to the meter voltage circuit. At this point, the register display will not light up.
 - b. Check to be sure that the register is energized by passing a magnet rod slowly by the left-hand side of the electronic module, near the magnetic display switch. The display will light up immediately and in a few seconds it will scroll through three positions, then stop, displaying a reading "Er 000011." This reading indicates that there is no battery installed and the register is not programmed. The meter can be calibrated in this state.
 - c. Calibrate the meter. Normally, the meter requires a minor light-load readjustment only, because of the minimal effect of the register transformer field.
7. Install the battery by using a magnet rod, with the cap end (-) of the battery attached to the rod. Push firmly inward until the hook on the battery holder (see Fig. 6) snaps in place.
8. Install the time-of-use meter cover.
- a. De-energize the meter.
 - b. Plug the communication port cable connector, located in the cover, onto the three-pin connector that is located just to the right of the battery holder. See Fig. 6. Be sure to observe proper polarity by assembling the connector with the cable pointing downward as shown; also make certain that all three pins are engaged. Otherwise, the register will not program.
 - c. Move the cover down over the meter, dressing the communication port cable down the right side of the register. Assemble the cover so that the access port and/or the maximum demand reset mechanism is directly over the register battery holder.
9. Functional test of the meter and register.
- a. Energize the meter at rated voltage and apply a load sufficient to turn the rotor at a reasonable speed.
 - b. Light up the display by slowly passing the magnet rod by the left side of the register. This assures that the register is energized.
 - c. Program the register.

NOTE: Use a portable programmer that is compatible with the TM-80 register. Follow the procedure listed under "Programming", page 23, and insert a K (K_h on some programmers) of 999.999.

- (1) Check the display to see that kilowatt-hours are accumulating.
 - (2) Check to be sure that no battery error (Er 000001) is displayed.
 - (3) Manually reset the maximum demand and check to be sure that all 8's are displayed.
10. Prepare the time-of-use meter for storage or installation.
- a. De-energize the meter.
 - b. Open the access port on the cover or remove the cover if there is no access port. Use the magnet rod to push the battery-holder hook (Fig. 6) to the right, then remove the battery with the magnet rod.
 - c. Close and lock the access port or replace the cover. When replacing the cover, follow the procedure listed in Step 8 above.
11. The meter is now ready for storage or installation. For field installation, install a new battery, energize the register, then program with your billing program.

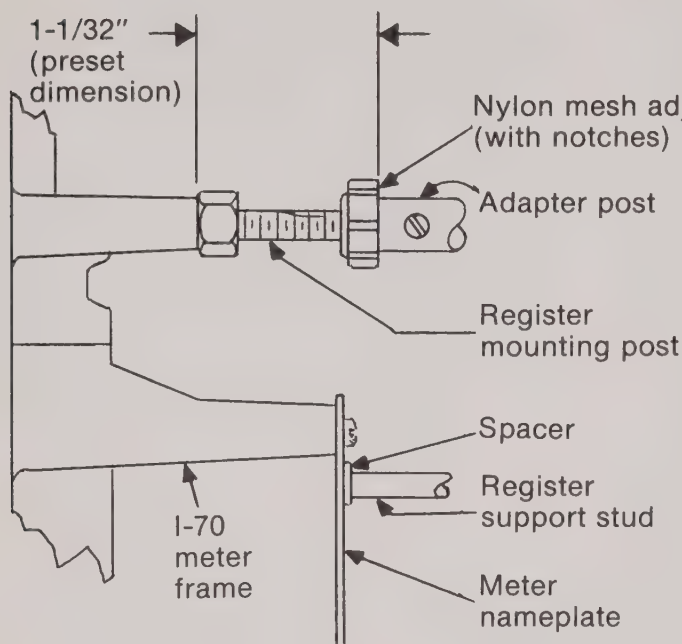
CONVERSION TO "RM" TYPES

If it is desired to convert field-installed watthour meters for acceptance of the TM-80 register, conversion kits are available. The kits include a new cover, new rotor assembly (if required), power leads, mounting posts, register support studs, etc., the exact kit contents varying for each type of meter. Contact your nearest General Electric Representative or Sales Office for your specific application. Refer to Instruction Book GEI-52503 for conversion instructions.

USE WITH A PULSE INITIATOR

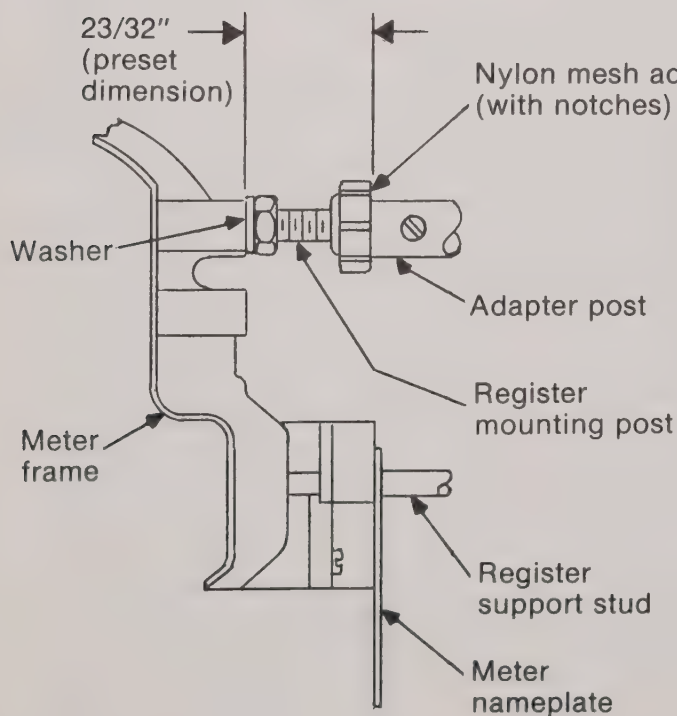
The following pulse initiators are compatible for use with a Type TM-80 TOU register on a watthour meter:

1. Types D-52 and D-72 for polyphase watthour meters.
2. Types D-53 and D-73 for Type I-70 single-phase watthour meters.



Approx. Depth of Mesh	Number of Notches Moved from Topping Position
1/3 mesh	1 1/4 - 1 1/2
1/2 mesh	2 - 2 1/4
2/3 mesh	2-3/4 - 3

Fig. 11. TM-80 register mounting and mesh adjustment on Type I-70 meters.



Approx. Depth of Mesh	Number of Notches Moved from Topping Position
1/3 mesh	1 1/4 - 1 1/2
1/2 mesh	2 - 2 1/4
2/3 mesh	2-3/4 - 3

Fig. 12. TM-80 register mounting and mesh adjustment on polyphase and switchboard meters.

The installation procedure for these pulse initiators is unaffected by the addition of the TM-80 register to a watthour meter. The one minor difference is that shorter TM-80 register support studs (see Figs. 11 and 12) must be used. The TM-80 conversion kits contain two lengths of support studs for "with" and "without" the pulse initiator.

When mounting a pulse initiator on a meter with an existing TM-80 register, the shorter support studs must be obtained along with the pulse-initiator conversion kit.

OPERATING PROCEDURES

PREPARATION FOR PROGRAMMING

1. Make sure that the watthour meter and the TM-80 register are of the same voltage rating.
2. Install the meter.
3. Energize the meter at rated voltage. The voltage should be "snapped on" and not gradually turned up.
4. Open the access port in the meter cover and, using the magnet rod, insert a battery (cap end out) into the battery holder of the register.

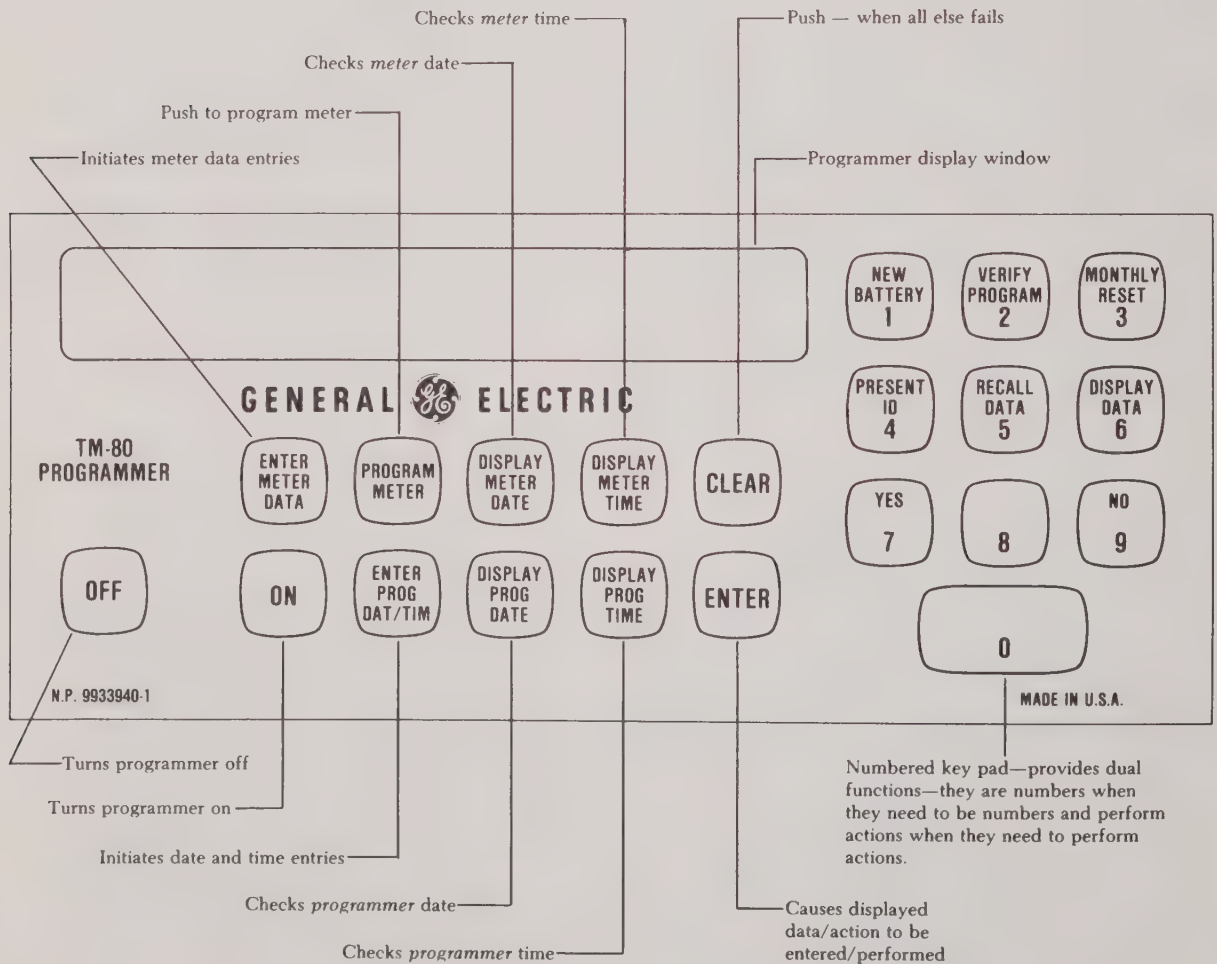


Fig. 13. Location of keys on programmer front plate.

5. Pass the magnet rod slowly by the left side of the register. The magnetic display switch on the logic printed circuit board (Fig. 5) will close and cause the register display to light up. Initially, nine zeros will be displayed, followed by 01 and a series of numbers, 02 and more numbers, 03 00000, and then ER 000010. The latter is an error code which indicates there is no program in the meter. The meter is now ready to be programmed. It is not essential to light the display prior to programming. However, lighting the display is a ready way to ensure that the register is energized.

PROGRAMMING

Before attempting to program a TM-80 register, the following information must be available:

1. Date
2. Time (military, 0 to 23 hours)
3. Keyword
4. Meter code number
5. K (programming watthour constant)
6. Transformer factor (TF)
7. Decimal position
8. Program number
9. Program ID

See Fig. 13 for the positioning of the programmer keys. These keys are referred to in the following programming procedure.

1. Push the programmer ON key.
2. Push the ENTER PROG DAT/TIM key.
3. "ENTER KEYWORD" will be displayed.
4. Punch in the keyword.
5. Push the ENTER key.
6. The year (XX) will be displayed.
7. Punch in the desired year (two digits).
8. Push the ENTER key.
9. The month (XX) will be displayed.
10. Punch in the desired month.
11. Push the ENTER key.
12. The day (XX) will be displayed.
13. Punch in the day of the month.
14. Push the ENTER key.
15. The hour (XX) will be displayed.
16. Punch in the hour (military time, 0 to 23 hours).

17. Push the ENTER key.
18. The minutes (XX) will be displayed.
19. Punch in the minutes.
20. Push the ENTER key.
21. The seconds (XX) will be displayed.
22. Punch in the seconds.
23. Push the ENTER key.
24. "P : XX Hrs. : XX Min. : XX Seconds" will be displayed.
25. Push the ENTER key.
26. The prompt (Δ) will be displayed.
27. Push the DISPLAY PROG DATE key.
28. The day of the week/day of the month/month/year will be displayed.
29. Push the DISPLAY PROG TIME key.
30. "P : XX Hrs. : XX Mins. : XX Seconds" will be displayed.
31. Push the ENTER METER DATA key.
32. "METER CODE : 000000000" will be displayed.
33. Punch in the new meter code number if desired. If not, proceed.
34. Push the ENTER key.
35. "K = 007.200" will be displayed. (On early production programmers K_h is used rather than K.)
36. Punch in the new programming watthour constant (K) if desired. Punch in the digits you want, then move the digits to the left by punching the zero key until the decimal point is in the correct position.
37. Push the ENTER key.
38. "TRANS. FACTOR 000001" will be displayed.
39. Punch in the new transformer factor (multiplier) if desired.
40. Push the ENTER key.
41. "DECIMAL POSITION = 02" will be displayed.
42. Punch in the desired decimal position 1, 2, or 3. The decimal point position is movable only in the demand kW readings, and the number selected indicates the number of digits to the right of the decimal point. If the possible kW is less than 10, use three decimal places; if the kW is 10 to 99, use two decimal places; if 100 or more, use one decimal place.
43. Push the ENTER key.
44. The prompt (Δ) will be displayed.

45. Connect the programmer probe to the communication port in the front of the meter cover.

46. Push the PRESENT ID key.

47. "PRESENT ID = 00" will be displayed.

48. Punch in the ID. If the register contains no program, use an ID of 00. If the register is already programmed, use the ID that is presently in the TM-80 register.

49. Push the ENTER key.

50. The prompt (Δ) will be displayed.

51. Push the PROGRAM METER key.

52. "PROGRAM NUMBER = 00" will be displayed.

53. Punch in the correct program number, 1 thru 4.

54. Push the ENTER key.

55. "PROGRAMMING METER" will be displayed.

56. "FINISHED PROGRAMMING" will be displayed. If the display fails to sequence, activate it with the magnet rod.

OTHER FUNCTIONS OF THE PROGRAMMER

NEW BATTERY - When a new battery is installed, push this key (see Fig. 13). The display will read: "NEW BATTERY?"; push the YES key.

Push the ENTER key. The display will read: "ZEROING BATTERY TIME" and then "BATTERY TIME CLEARED." This indicates that the recorded time on battery has been erased and returned to zero.

VERIFY PROGRAM - If you wish to verify the program in the register, you must punch into the programmer the ID that is in the register. Then push the VERIFY PROGRAM key and "PROGRAM NUMBER : 00" will be displayed.

Push the ENTER key. If the program in the register matches the program number displayed, the programmer display will read "PROGRAM VERIFIED"; if not, it will read "PROGRAM NOT VERIFIED." If it is not verified, it indicates the program in the register is different from the selected program. Now press the VERIFY PROGRAM key and punch in another program number (1 thru 4). Continue until the program verifies.

If the register has not properly retained the program, it will display the RAM error code Er 000100. The programmer will read "TRANSMISSION ERRORS."

MONTHLY RESET - The maximum demand may be reset with the programmer. To accomplish this, the

ID in the programmer must match that in the register. Push the MONTHLY RESET key. The display will respond with "MONTHLY RESET?"; push the YES key and then the ENTER key. The display will read "RESETTING METER" and then "FINISHED MONTH RESET." At the same time the register will display all 8's.

DISPLAY DATA - To have the programmer display the meter data, push the DISPLAY DATA key; the display will respond with "READING METER." Then, by repeatedly pushing the ENTER key, the meter data will be displayed in sequence. Also available is some information which may not be displayed by the register. This additional data is programmable.

RECALL DATA - To recall data from the last meter reading, push the RECALL DATA key and then the ENTER key. In order for this to function, you must have used the Display Data on the last meter and you must not have pushed the PROGRAM METER or VERIFY PROGRAM keys since that time.

PROGRAMMING PITFALLS

Program ID

In order for the programmer to communicate with the TM-80 register, and vice versa, the ID must be the same in both. The present ID displayed by the programmer is the ID that is in the programmer but not necessarily the one in the register.

When starting with a register having no program in it, the ID is always 00, but as soon as any program is inserted into it, the register assumes the ID from that particular program. You must know what that ID is. Then punch that ID into the programmer and push the ENTER key. The programmer and register can then "talk" to each other. If you change the program again, you must remember to punch in the new ID and ENTER so that the two devices can continue to communicate. Anytime the programmer displays "TRANSMISSION ERRORS," probably the ID's do not match.

Recall Data

In order to recall data, remember that the data must first be displayed, or the information from the register will not be in the programmer to be recalled. Also, between the time you ask the programmer to display data and recall data, you cannot push the PROGRAM METER key or the VERIFY PROGRAM key. If they are pushed, the programmer's memory will be erased.

DISPLAY OPERATION

The information contained within the TM-80 register is presented to the customer by means of a 9-digit

vacuum fluorescent display. Up to 33 pieces of meter data can be displayed sequentially. Each piece of information is normally displayed for approximately seven seconds unless otherwise specified. This "On Time" for each displayed quantity is programmable from one to 14 seconds, and selectable on the rate schedule sheet made out by you for preparation of your programmer PROM. The total daily "On Time" (for example, 6:00 AM to 6:00 PM) is also programmable and selectable on the rate schedule sheet.

Using the magnet rod, the display can be made to operate in the manual mode as follows:

1. Reset to the first quantity, then scroll through all quantities in the normal manner. To do this, pass the magnet rod slowly by the left side of the register so that the magnetic display switch is closed more than one second but less than three seconds.

2. Fast step through the displayed quantities, then stop and hold on a specific quantity for five minutes. To do this, hold the magnet rod in position to close the magnetic display switch for a time more than three seconds. The display will start the fast scroll and continue until the magnet rod is removed. At that point, the display will hold on that displayed quantity for five minutes. After the five-minute time period, the display will revert to its normal display sequence of approximately seven seconds per quantity.

3. Manually step through the displayed quantities sequentially. To do this, get the display into the fast step mode (as described in Step 2 above), then remove the magnet rod. The display will stop, then for five minutes hold on the quantity at which the magnet rod was removed. The display can then be stepped to the next quantity by passing the magnet rod by the magnetic display switch to hold it closed more than one second but less than three seconds. Quantities displayed in this manner will hold up to five minutes each. If not stepped to the next quantity within five minutes, the display will revert back to its normal mode of operation. The display will revert to its normal mode of operation from the manual step mode by manually resetting maximum demand.

The TM-80 performs self-checking tests upon itself, one of which is a battery check. When a fault exists at the time a check is made, an error code will be displayed. Error codes and their meanings are listed in the Troubleshooting Guide, page 34. When displayed, they will hold until the display is reactivated by using the magnet rod and holding the magnetic display switch closed more than one second but less than three seconds. If the error persists, the error code will again be displayed and hold after the last displayed meter quantity.

A battery check is performed each time the magnet rod is used to reset the display. This eliminates the need

for having to wait for the normal check at midnight, if a battery check is desired.

DEMAND RESET

The maximum demand can be reset to zero by two different means. It can be reset manually by turning the reset mechanism in the cover counterclockwise. When this method is used, the reset arm contacts a lever extending from the front of the register. A display of all 8's confirms that the demand has been reset.

The maximum demand can also be reset using the programmer. At the completion of the resetting process, the programmer will display "FINISHED MONTH RESET" and the register will display all 8's.

REPROGRAMMING

A TM-80 register is usually reprogrammed for the purpose of inserting a new program. The register is programmed in the usual manner, with care being taken to match the ID in the programmer with the present ID in the register. Do not inadvertently change the programming watt-hour constant. If this happens, the new constant will be applied to stored data as well as future data.

BATTERY REPLACEMENT

The purpose of the battery in the TM-80 register is to maintain timekeeping and stored data during a power outage. It is a nonrechargeable lithium battery with a life of five years and a carryover time of 40 days.

The expended battery time, that is, the amount of time which the register has actually been on battery power, is a displayable quantity. It is measured and displayed in minutes. The TM-80 automatically performs a battery check every 24 hours at midnight.

When the battery is discharged or removed from the battery holder, the display will read Er 000001 after this check is performed. The display sequence will stop at this step. In order to retrieve stored data, the magnet rod must be passed by the left side of the register. This will cause the display sequence to start (see "Display Operation," page 24).

To replace the battery, open the access port or remove the meter cover, push the battery holder hook to the right, and with the magnet rod remove the battery. Make sure that the ac power to the meter is on. If both the ac power and the battery are removed at the same time, the register's timekeeping, stored data, and program will be lost.

Install a new battery by using the magnet rod to insert it into the battery holder, cap end out. If the battery is installed backwards, the battery power carryover will not function. The programmer must be used to reset the expended battery time to zero.

TEST PROCEDURES

FAMILIARIZATION CHECKS

Familiarization checks of General Electric watt-hour meters with TM-80 registers are intended to ensure that all your anticipated time-of-use metering requirements can be met, as well as providing first-hand experience with this versatile, TOU register/meter combination. Both single-phase and polyphase watt-hour meters with TM-80 registers and portable programmers are available with typical rate schedules from the General Electric Company. Contact your nearest General Electric Sales Office or Representative for more information.

The following is a list of suggested checks:

1. Watthour meter characteristics.
2. Register performance over the operating temperature range.
 - a. Kilowatthour and kilowatt measurement plus demand reset.
 - b. Timekeeping both on ac line and in the power outage mode.
3. Rate schedule verification (see Section below).
4. Battery replacement.
5. Typical watthour meter physical and environmental tests.
6. Longer term billing-type application test.
7. Observe its operation under actual and simulated field conditions.

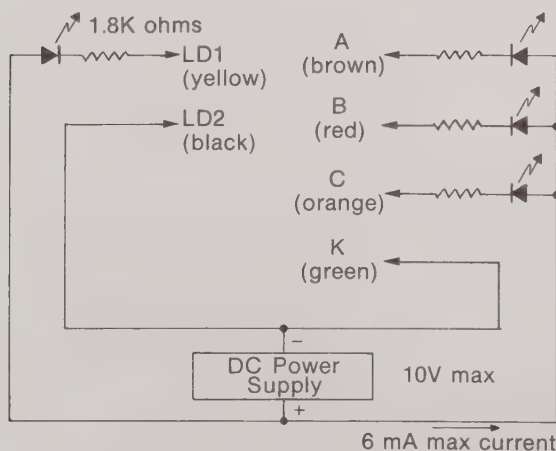


Fig. 14. Test circuit for load control and rate indicator outputs.

RATE SCHEDULE VERIFICATION

The purpose of rate schedule verification is to ensure that your programmed TM-80 registers provide the desired rate schedule. The rate schedule is predetermined by the replaceable user PROM's in your TM-80 programmer.

Rate schedule verification should be done every time new user PROM's are installed in programmers for a new schedule. It should also be done with the initial purchase of time-of-use watthour meters with TM-80 registers, either for familiarization checks or field installation. The time and actions should be verified on one of each new group of user PROM's received.

Recommended procedure:

1. First check the user PROM information sheet (received with the new PROM) against the desired rate schedule that you listed on the TM-80 program check list when you ordered the new PROM or programmer.
2. Confirm the following:
 - a. All on-off times and actions for the daily and weekend/holiday schedules for each season.
 - b. The displayed quantities for each season.
 - c. Daily total "on" time of display in hours (for example, 14 hours).
 - d. Total "on" time of display in seconds (for example, seven seconds).
 - e. Days of week that are on the weekend/holiday schedule.
 - f. The demand interval length.
 - g. Programmable dates for:
 - Holidays (midnight change).
 - Season changes (midnight change).
 - Daylight saving time change (2:00 AM change).
 - h. Time of delay in demand measurement after power outage (if this option was selected).

NOTE 1: When resetting time to check an action, set the TM-80 programmer time at least one minute before an action is to take place, then program the register. This allows the action to be more readily observed.

NOTE 2: When checking the daylight saving time change, set the programmer time at least one minute before midnight, then program the register. To observe the time change, wait two hours until 2:00 AM.

INCOMING CHECK

The purpose of the incoming check is to ensure that you have received the proper time-of-use TM-80 register or watthour meter/TM-80 register combination; also to ensure that there was no damage caused by shipment and that the device will function as desired. In general, the check should consist of both a visual inspection and a brief operating test. The following checks are recommended.

1. Visual inspection for:
 - a. Physical damage.
 - b. Watthour meter catalog number on both the register and watthour meter nameplates. The register catalog number is located on its curved nameplate.
 - c. Register ratio stamped on the ratio plate assembly (visible from top) and on the register front-plate ratio tab.
 - d. Voltage rating stamped on transformer (visible from top). It should agree with the system voltage.
 - e. Meter nameplate data. Make sure that it agrees with the meter as ordered.
 - f. Access port, if desired, and type of demand reset on cover.
 - g. Proper electrical connections:
 - (1) Thumb nut power leads to register transformer.
 - (2) Communication-port and cable assembly to register (see Figs. 4 and 6).
2. Operating test.
 - a. Calibration check. The TOU watthour meter with the TM-80 register is calibrated at the factory and normally does not require recalibration. However, if a calibration touch-up is desired, generally only a minor light-load adjustment is necessary. The calibration check should be done the same as on a typical watthour meter. However, the TM-80 should always be energized. The register carryover battery need not be installed. To check to be sure that the register is energized, pass a magnet rod slowly by the left-hand side of the electronic module, near the magnetic display switch (Fig. 5). The display will light up immediately, and in a few seconds it will scroll through three positions, then stop, displaying a reading "Er 000011". This reading indicates that there is no battery installed and the register is not programmed.
 - b. Register Check. The purpose of the register check is to ensure that your TM-80 accumulates

and displays metered quantities, keeps proper time, and provides your desired pulse resolution. It is not necessary that the check include a comprehensive rate schedule verification, since this is a check of the programmer PROM previously verified when initially received. The recommended procedure for register check is as follows:

- (1) Install the battery by using a magnet rod, with the cap end (-) of the battery attached to the rod. Push firmly inward until the hook on the battery holder (see Fig. 6) snaps in place.
- (2) Energize the meter at rated voltage and apply a load approximately equaling test amperes. This is sufficient to turn the rotor at a reasonable speed.

NOTE: *In the case of a register not mounted on a meter, it is suggested that the register be mounted on a meter fitted for this purpose or on a register test stand that will provide a known input (such as a synchronous motor driven from a 60 Hz ac power source) to the register drive gear. Rated ac voltage should also be supplied.*

- (3) Light up the display by slowly passing the magnet rod by the left side of the register. This assures that the register is energized.

- (4) Program the register.

NOTE: *Use a portable programmer that is compatible with the TM-80 register. Follow the procedure listed under "Programming", page 23, and insert a K (K_h on some programmers) of 999.999.*

- (a) Check the display to see that kWh's accumulated.
- (b) Check to be sure that no battery error (Er 000001) is displayed.
- (c) Manually reset the maximum demand and check to be sure that all 8's are displayed.

Timekeeping Check

Both the primary timekeeping (60 Hz line frequency-based) and the power carryover secondary timekeeping (crystal-based) should be checked using the register load control switch. When so doing, use the test circuitry for the load control switch as shown in Fig. 14. Use a programmer with a convenient program that will switch the load control switch on at least once per day.

1. Primary timekeeping.

The TM-80 register and the time checking clock used should be electrically energized from the same 60 Hz ac line. The clock should have a reading resolution of one second or better.

- a. Install a carryover battery.
- b. Set the programmer time approximately one minute prior to a load control switching action, then program the register.
- c. Note the lapsed time on the time checking clock over a 24-hour period between this particular load control action (light changes state). The load control action should take place at exactly the same time 24 hours later, provided the 60 Hz ac power has been *maintained continually* throughout this period.

2. Secondary timekeeping.

In this case, the time checking clock should be accurate with respect to real time and readable within one second maximum over a 24-hour period, and not use the 60 Hz line frequency as its primary time base.

- a. Install a carryover battery.
- b. Set the programmer time approximately one minute prior to a load control switching action, then program the register.
- c. Note the exact time to the second that the load control switching action takes place (light changes state). Then immediately turn off the ac power to the register and leave for slightly less than 24 hours.
- d. After this 24-hour period, at about one minute prior to the exact schedule time for the load control action to take place, switch the ac power to the register back on.
- e. Note the exact time, to the second, that the load control action takes place. The difference between the two readings over the 24-hour period should be within nine seconds. This limit applies over the entire operating temperature range.

Pulse Resolution

Pulse resolution from TM-80 optics assemblies with either the 2-, 4-, or 8-slot shutters can be determined as follows:

1. Install a carryover battery and energize the register at rated voltage.
2. Program the TM-80 with any convenient program inserting a K (or K_h) value of 999.999.

3. For registers mounted on watthour meters, run the watthour meter at test amperes (full load) for one minute. Resolution can be determined from the following table.

Kilowatthours Accumulated per Minute	Resolution Pulses per Meter Disk Rev.		Number of Shutter Slots
	Single-phase	Poly-phase	
8	0.5	1	2
17	1	2	4
33	2	4	8

NOTE: *Accurate timing and control of test amperes is not required, since kWh's accumulated close to the above values will permit determination of resolution.*

4. For registers mounted on test stands, both the synchronous speed (rpm) and the number of teeth on the gear driving the register drive gear has to be known. The synchronous drive is then run for one minute and the resolution is calculated as follows:

$$\text{Resolution} = \frac{(\text{kWh accum./minute}) \times 20}{\text{Rpm of syn. drive} \times \text{No. of gear teeth on syn. drive}}$$

APPLICATION INFORMATION

SELECTION OF METER CONSTANTS

There are four meter constants that are inserted into the register memory by the programmer to ensure proper output of meter information to a portable reader and/or the register display. They are:

1. Meter Code Number.

A nine-digit number that will allow 999,999,999 different meter code numbers to be used.

2. Programming Watthour Constant (K).

A six-digit number that can vary from 0.025 to 999.999 and normally equals the K_h of the watthour meter. The optics assembly on the TM-80 register feeds pulses to the electronic module. The standard shutter configuration in the optics assembly (two for poly-phase and four for Type IRM-70 meters) produces one pulse per revolution of the watthour meter disk. The value of each pulse in watthours is the programming watthour constant (K). Two-, four-, and eight-slot shutters are available and, should a resolution other than that equaling the K_h be desired, any one of the three shutters can be used.

The programming watthour constant can be calculated by the formula $K = K_h \times \text{register R/P}$, using the following register R/P values:

Meter Types	2-slot Shutter	4-slot Shutter	8-slot Shutter
	Register R/P		
Polyphase Meters	1/1*	1/2	1/4
IRM-70 Meter	2/1	1/1*	1/2

*Standard shutter configurations.

Table 5 (page 33) lists programming watthour constants (K) for the more commonly used General Electric watthour meters.

3. Transformer Factor (TF). $TF = CT \text{ ratio} \times VT \text{ ratio}$.

A six-digit number, primarily for use with a portable reader only. The transformer factor for the installation can be used to multiply the kilowatthour and demand readings to obtain primary readings. The readings displayed by the TM-80 register are secondary readings which are not affected by the transformer factor.

4. Decimal Position.

Used to obtain the desired resolution for kilowatt demand readings. When positioning the decimal point in the demand reading, it is recommended to use three decimal places when a meter has a maximum capacity of less than 10 kilowatts. For meters with capacities from 10 to 99, use two decimal places, while for those of 100 or more use one decimal place. Table 4 (page 31) lists the recommended positioning of the decimal point for the more commonly used General Electric watthour meters.

LOAD CONTROL AND RATE INDICATOR OUTPUT OPTIONS

If rate indicator and/or load control outputs are required, cable assemblies are available for making the connections internally on the register. The cables pass through the meter base and extend into the meter socket. These cables may be ordered factory-assembled to the meter or as a supply item. Two different internal cable assemblies are used, one for polyphase meters and another for single-phase meters. If ordered as a supply item, the meter type must be specified. Contact your nearest General Electric Representative or Sales Office for ordering information.

Each cable has six leads for connection to the register terminal boards, as shown in Fig. 15. Six leads are always supplied and connected, even though in some cases only two will be used to provide output from a single output. When ordering a time-of-use meter with a TM-80 register, or a register separately, the number of rate indicator outputs (0, 1, 2 or 3) and the combinations desired (A, AB or ABC) must be specified, since each is a built-in feature on the power supply board and will be supplied as ordered. These combinations are shown on Fig. 14. Also, specify the load control, if desired.

Application of Outputs

In order to apply the load control and rate indicator outputs, cable assemblies shown in Fig. 15 must be installed on the watthour meter to electrically connect to the switches. The following procedure should be used when installing:

1. Remove plug from the hole in the meter base (located on left side for IRM-70; at the bottom for VRM-60 meters).

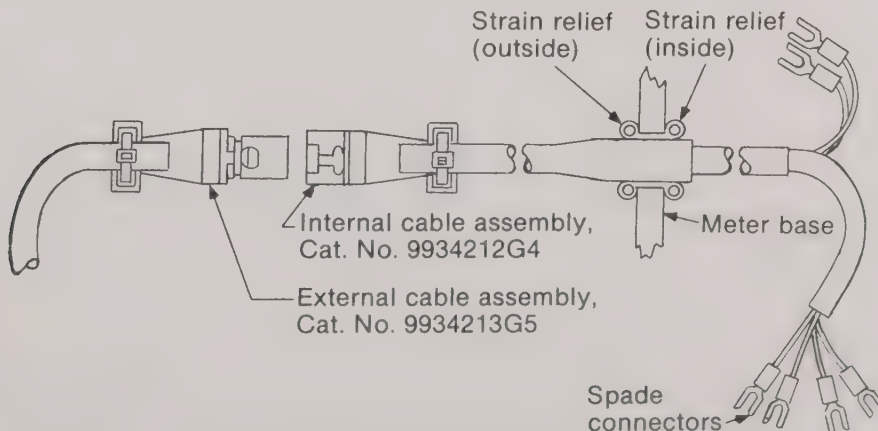


Fig. 15. Internal and external cable assemblies.

2. Insert the internal cable assembly -- spade connectors first -- through the hole from the outside in. Pull through until the cable extends through the meter base, as shown on Fig. 15.

3. Crimp one strain relief on the cable on the inside of the meter base, then pull the cable back until the strain relief is firmly against the base.

4. Crimp the second strain relief firmly against the outside of the base.

5. Electrically connect the spade connectors as shown on Fig. 16 or 17. Dress the cable up the left side of the meter and under the meter nameplate, ensuring no interference with the meter disk and calibration screws.

At the rear of the TM-80 register module is the power supply board (see Fig. 5). This board can have two different configurations, either "REV B" or "REV D," as shown in Figs. 16 and 17. The REV B board (Fig. 16)

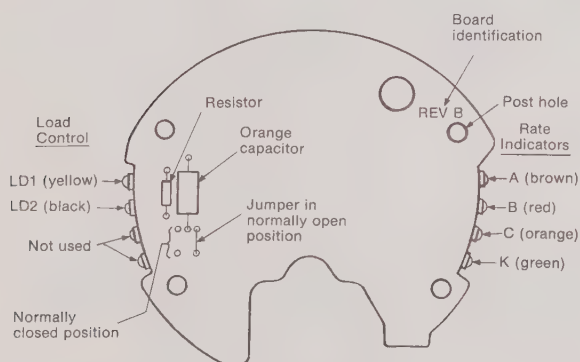


Fig. 16. Power supply board identified as "REV B," showing cable terminals for load control and rate indicators.

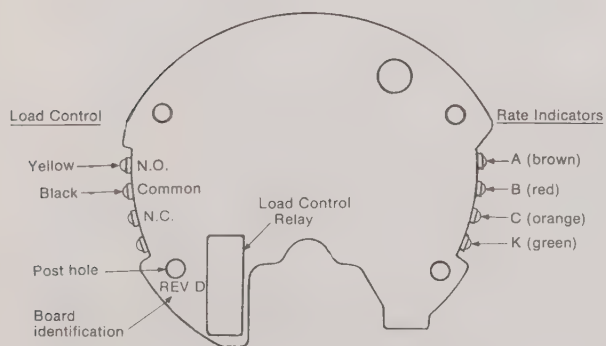


Fig. 17. Power supply board identified as "REV D," showing cable terminals for load control and rate indicators.

has its identification in the upper right corner near the post hole, while the REV D (Fig. 17) is located in the lower left corner.

For the REV B board (Fig. 16), load control connections are made on the left side to terminals LD1 and LD2. The load control switch is set at the factory in the normally open position with the jumper as shown. If the normally closed condition is desired, the jumper must be unsoldered and then resoldered in the left-hand position across the two solder points identified as "Normally closed position." The arc-suppression circuit limits the application of this board to 120 volts. The rate-indicator switch connections are always made as shown.

For the REV D board (Fig. 17), the normally open state of the load contacts is obtained by connecting the yellow lead to the upper left terminal. To obtain the normally closed state, connect the yellow lead to the third terminal down on the left (marked N. C.). The arc-suppression circuit limits the application of this board to 120 volts.

The recommended test circuit for the load control and rate indicator outputs is shown in Fig. 14.

CAUTION: RATE INDICATOR OUTPUTS ARE SEMICONDUCTORS. IN TEST OR APPLICATION, CORRECT POLARITY MUST BE OBSERVED. THE VOLTAGE AND CURRENT RATINGS MUST NOT BE EXCEEDED; OTHERWISE, THE CIRCUIT CAN BE DAMAGED.

The load control switch is a mercury-wetted relay with SPDT, 3-wire, Form C contacts rated at two amperes maximum and 500 volts peak, with the combination of volts times amperes not to exceed 100 volt-amperes. The load control circuitry includes arc suppression as shown in Figs. 18 and 19.

The relay will provide long life when operated within the rating of the contacts and when the proper arc suppression is used. If additional arc suppression is needed, it must be applied at the load being switched by the load control relay. Values of resistance and capacitance in the added RC circuit of the added arc suppression can be selected from the relay manufacturers' nomograph, shown in Fig. 20. If need be, contact your nearest General Electric Representative or Sales Office for further arc-suppression recommendations.

CAUTION: BEFORE APPLYING LOAD TO THE CONTACTS, BE SURE THAT THE METER IS IN ITS NORMAL OPERATING POSITION; OTHERWISE, THE MERCURY-WETTED CONTACTS MAY BE DAMAGED.

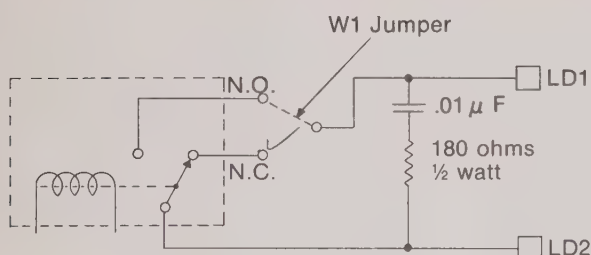


Fig. 18. Load control circuit for registers with REV B power supply board.

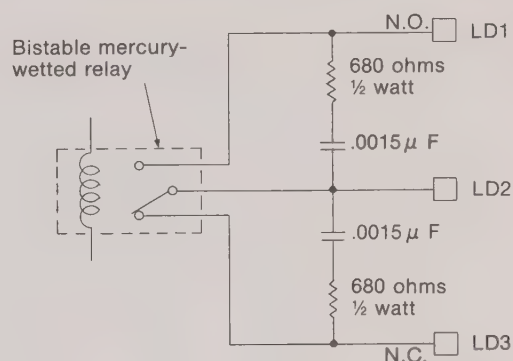
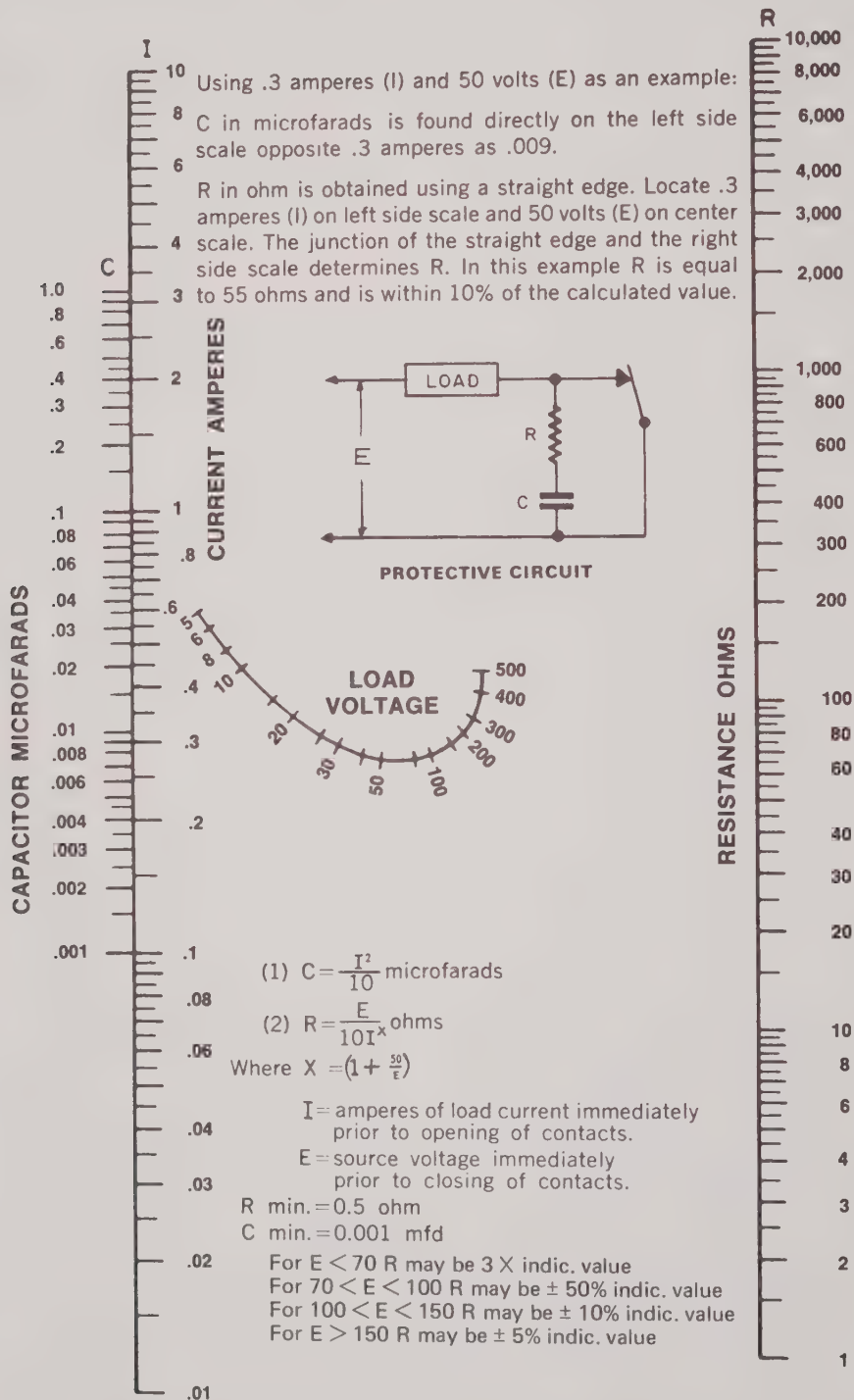


Fig. 19. Load control circuit for registers with REV D power supply board.

TABLE 4
TM-80 DISPLAY OF DEMAND READINGS

Watthour Meter Type	Volts	Class	K _h	Class kW*	Suggested Decimal Location and Display Values (at Class Load)
I-70	120	10	0.3	1.2	01.200
	120	100	1.8	12	012.00
	240	10	0.6	2.4	02.400
	240	100	3.6	24	024.00
	240	200	7.2	48	048.00
	240	320	12	76.8	076.80
	480	100	7.2	48	048.00
	480	200	14.4	96	096.00
V-62, -63	120	10	1.2	2.4	02.400
	120	20	1.2	4.8	04.800
	120	100	7.2	24	024.00
	120	200	14.4	48	048.00
V-62, -63, -66	240	10	2.4	4.8	04.800
	240	20	2.4	9.6	09.600
	240	100	14.4	48	048.00
	240	200	28.8	96	096.00
V-62, -63	480	10	4.8	9.6	09.600
	480	20	4.8	19.2	019.20
	480	100	28.8	96	096.00
	480	200	57.6	192	0192.0
V-64, -65	120	10	1.8	3.6	03.600
	120	20	1.8	7.2	07.200
	120	100	10.8	36	036.00
	120	200	21.6	72	072.00
	240	10	3.6	7.2	07.200
	240	20	3.6	14.4	014.00
	240	100	21.6	72	072.00
	240	200	43.2	144	0144.0

*Class kW = $\frac{\text{Rated Volts} \times \text{Class Amps.} \times \text{No. of Stators}}{1000}$



NOTE: Max contact current 2 amps, max voltage 500 volts, with combined volt-amps not to exceed 100.

Fig. 20. Nomograph for use in selecting the correct external arc suppression.

TABLE 5
PROGRAMMING WATTHOUR CONSTANTS

Watthour Meter Type	Class	Volts	K_h	Direct and Secondary Reading (R_r) (x 1)	TM-80 Programming Watthour Constants (K)		
					2-slot Shutter	4-slot Shutter	8-slot Shutter
I-70	10	120	0.3	333 1/3		0.3	0.15
	10	240	0.6	166 2/3		0.6	0.30
	100	120	1.8	55 5/9		1.8	0.90
	100	240	3.6	27 7/9		3.6	1.80
	100	480	7.2	13 8/9		7.2	3.60
	200	240	7.2	13 8/9		7.2	3.60
	200	480	14.4	6 17/18		14.4	7.20
	320	240	12.0	8 1/3		12.0	6.00
V-62, -63	10	120	1.2	166 2/3	1.2	0.6	0.30
	10	480	4.8	41 2/3	4.8	2.4	1.20
	20	120	1.2	166 2/3	1.2	0.6	0.30
	20	480	4.8	41 2/3	4.8	2.4	1.20
	100	120	7.2	27 7/9	7.2	3.6	1.80
	100	480	28.8	6 17/18	28.8	14.4	7.20
	200	120	14.4	13 8/9	14.4	7.2	3.60
	200	480	57.6	3 17/36	57.6	28.8	14.40
V-62, -63, -66	10	240	2.4	83 1/3	2.4	1.2	0.60
	20	240	2.4	83 1/3	2.4	1.2	0.60
	100	240	14.4	13 8/9	14.4	7.2	3.60
	200	240	28.8	6 17/18	28.8	14.4	7.20
V-64, -65	10	120	1.8	111 1/9	1.8	0.9	0.45
	10	240	3.6	55 5/9	3.6	1.8	0.90
	20	120	1.8	111 1/9	1.8	0.9	0.45
	20	240	3.6	55 5/9	3.6	1.8	0.90
	100	120	10.8	18 14/27	10.8	5.4	2.70
	100	240	21.6	9 7/27	21.6	10.8	5.40
	200	120	21.6	9 7/27	21.6	10.8	5.40
	200	240	43.2	4 17/27	43.2	21.6	10.80

MAINTENANCE AND TROUBLESHOOTING

REGISTER MAINTENANCE

The TM-80 register is an extremely low maintenance device. Other than cleaning and replacing damaged parts, there is little else that is necessary. The gearing and nameplates can be cleaned with solvent. The rest of the register can be dusted off with low-pressure compressed air. Do not ultrasonically clean or immerse the following parts in liquid:

- Transformer

- Optics assembly
- Printed circuit boards
- Battery
- Antiglare window

REGISTER HANDLING AND STORAGE

The TM-80 register is a durable device, but should be handled and stored with care.

The register should always be stored either on a meter and protected by the meter cover or on the shipping bracket and covered with a plastic bag. It should never be stored with a battery installed. Temperature

GEH-2792, Type TM-80 Time-of-Use Register

and humidity in the storage area are not critical, but extremes of either should be avoided.

Whenever the register is removed from the meter or shipping bracket, the electronic assembly and the adapter assembly should be laid faceup on a clean, flat surface.

The customer is not encouraged to disassemble the electronic module. When handling and storing the module, reasonable care must be taken not to damage the electronic circuitry due to static discharge.

HANDLING OF METER COVERS

The meter covers used with TM-80 registers are made of LEXAN resin. Care must be taken in cleaning the cover. No abrasives should be used, and any solvents should be chosen with care since they may attack it. Meter covers should not be marked with felt tipped pens as the ink may etch the surface.

BATTERY STORAGE

The TM-80 carryover battery should be stored in a well-ventilated area at +10 C to +30 C at a 50-percent relative humidity. The battery should be stored in its shipping container and not left in a TM-80 register that is not in service. Anytime a battery is installed in a register and the register is not energized with ac voltage, the battery is discharging.

TROUBLESHOOTING GUIDE

The following Troubleshooting Guide will enable users of TM-80 registers to overcome the more common problems encountered in programming and in using this device. While the TM-80 is sophisticated in design, it is quite simple to use once one becomes familiar with it and it's accompanying terminology.

TROUBLESHOOTING GUIDE

TROUBLE	PROBABLE CAUSE	REMEDY
1. Display not lighted.	a. Register not energized with rated ac voltage. b. Display in nighttime mode.	a. Energize register. b. Actuate display with magnet rod.
2. Display shows a continuous Er 000001.	a. Battery not installed. b. Battery installed backwards. c. Battery defective.	a. Install battery and initiate display sequence with magnet rod. b. Install battery correctly and initiate display sequence with magnet rod. c. Replace battery and initiate display sequence with magnet rod.
3. Display shows a continuous ER 000010.	a. Register not programmed.	a. Program register.
4. Display shows a continuous Er 000011.	a. Combination of Er 000010 and Er 000001.	a. See above for Er 000010 and Er 000001.
5. Display shows a continuous Er 000100 or Er 000101 or Er 000110 or Er 000111	a. RAM error in combination with other errors.	a. Replace electronic module.
6. Display shows a continuous Er 001000 or Er 001001 or Er 001010 or Er 001011 or Er 001100 or Er 001101 or Er 001110 or Er 001111	a. ROM error in combination with other errors.	a. Replace electronic module.

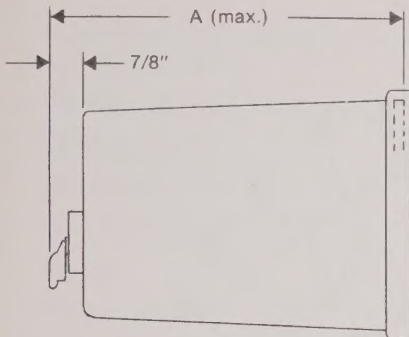
TROUBLESHOOTING GUIDE (Cont'd.)

TROUBLE	PROBABLE CAUSE	REMEDY
7. Display "stuck" and showing one number continuously.	a. Display in step mode.	a. Use magnet rod to advance display.
8. Magnet rod will not activate, initialize or advance the display.	a. Magnetic rod not positioned properly. b. Magnetic display switch damaged or defective.	a. Hold magnet rod against meter cover and parallel to magnetic display switch on logic board (see Fig. 5). b. Replace electronic module.
9. Register loses program and data during power outage.	a. Battery not installed. b. Battery installed backwards. c. Battery defective.	a. Install battery. b. Install battery correctly. c. Replace battery.
10. No accumulation of kilowatt-hours on mechanical register or digital display.	a. Register not properly meshed.	a. Adjust register mesh.
11. Kilowatthour accumulation on mechanical register does not agree with digital display.	a. Mechanical register and digital display did not both start from zero. b. Register not programmed with proper K_h . c. Mechanical R_r is incorrect. d. Shutter disk has incorrect number of slots.	a. Zero both registers. b. Reprogram with proper K_h . c. Replace ratio assembly. d. Replace adapter assembly.
12. Accumulation on mechanical register only.	a. Register not energized with rated ac voltage. b. Optics assembly defective. c. Electronic module defective.	a. Energize register. b. Replace adapter assembly. c. Replace module.
13. Meter calibration is slow or erratic.	a. Deep mesh between the register drive gear and the rotor pinion.	a. Adjust register mesh.
14. Load control does not function.	a. Lead assembly is not connected. b. Electronic module is defective.	a. Connect the lead assembly. b. Replace module.
15. Alert lights do not function.	a. Lead assembly is not connected. b. Electronic module is defective.	a. Connect the lead assembly. b. Replace module.

TROUBLESHOOTING GUIDE (Cont'd.)

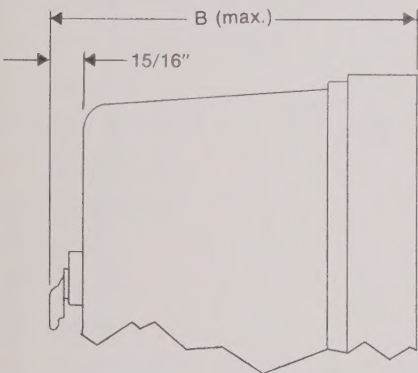
TROUBLE	PROBABLE CAUSE	REMEDY
16. Manual-demand reset does not display all 8's.	a. Electronic module is defective. b. Reset mechanism does not contact the lever in the register.	a. Replace module. b. Replace meter cover.
17. Programmer displays METER NOT RESPONDING.	a. Programmer probe not connected to meter. b. Register not energized with a rated ac voltage. c. Communication port cable inside meter cover not connected to the register. d. Defective cover assembly. e. Defective electronic module.	a. Connect probe. b. Energize register. c. Remove cover and connect cable. d. Replace cover assembly. e. Replace module.
18. Programmer displays TRANSMISSION ERRORS.	a. ID code in meter does not match present ID in programmer. b. Defective electronic module.	a. Change present ID in programmer to match ID of program in the meter. b. Replace module.
19. Programmer displays WRONG YEAR FOR PROG.	a. Wrong date entered in programmer.	a. Change date entered in programmer.
20. Programmer displays NO PROG FOR THAT ID.	a. Present ID in programmer not contained in PROM.	a. Change present ID in programmer to one contained in the program PROM.
21. Programmer display flashes.	a. Programmer battery is low.	a. Recharge battery.
22. Programmer display is blank and will not turn on.	a. Fuse missing or blown.	a. Install new fuse.
23. Programmer will not recall data.	a. Data was not displayed before being recalled. b. Either the PROGRAM METER key or VERIFY PROGRAM key was pushed before recall data, thus erasing the stored meter data in the programmer.	a. Display the data before recall, then perform operation. b. Display the data before recall, then perform operation.

METER DIMENSIONS



"S" Type Meters	Dimension A (in.)
IRM-70	7-1/2
VRM-62, -63	9-1/16
VRM-64	9-9/16
VRM-65, -66, -68	9-1/16

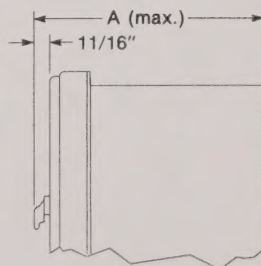
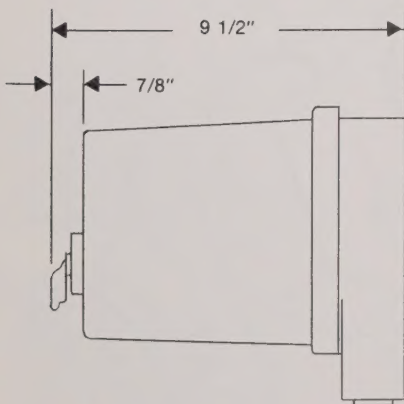
(a) Socket-connected (S) meters, Types IRM and VRM (also IRMW and VRMW).



"A" Type Meters	Dimension B (in.)
VRM-62, -63	9-9/16
VRM-64	10-1/16
VRM-65, -66, -68	9-9/16
VRM-63-2A	9-11/16
VRM-64-2A	10-3/8
VRM-65-2A	9-11/16

(b) Bottom-connected (A) meters, Types VRM (also VRMW).

Fig. 21. Dimensions of IRM and VRM meters having standard reset with port or with dual lock reset.



Meter Type	Dimension A (in.)
DSRM-53	9-11/16
DSRM-54	9-7/16
DSRM-55	9-11/16
DSRM-60	9-7/16
DSRM-63	9-11/16
DSRM-64	9-7/16
DSRM-65, -66	9-11/16
DSRM-67, -69, -163	9-7/16
DSRM-165, -166	9-7/16

Fig. 22. Dimensions of Type IRM-70 S/A meter/adaptor package (also Type IRMW). Its cover has standard reset with port or with dual lock reset.

Fig. 23. Dimensions of DSRM-50 and DSRM-60 families of meters (also DSRMW). The cover has standard reset without port.

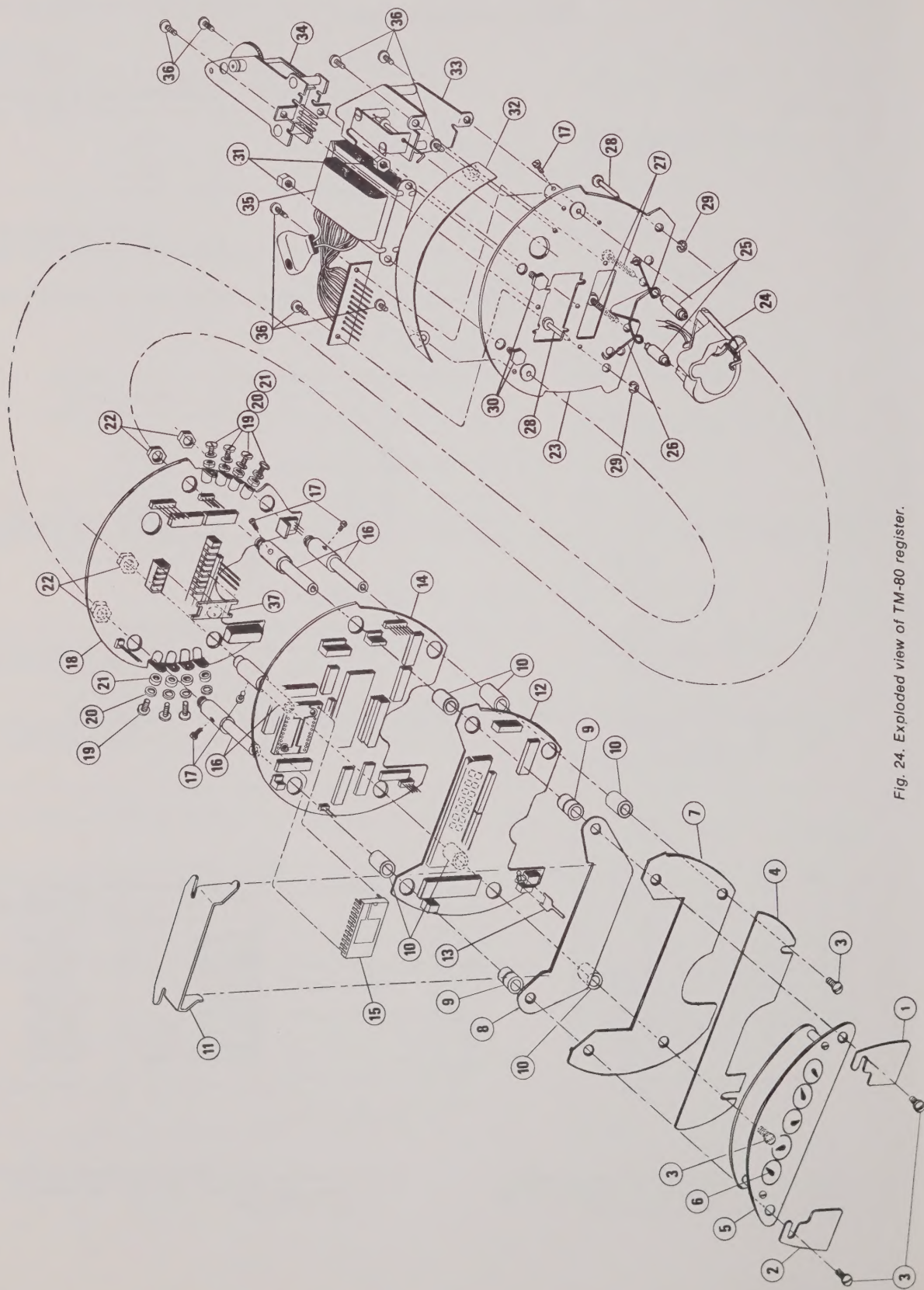


Fig. 24. Exploded view of TM-80 register.

TM-80 REGISTER NOMENCLATURE LIST

(See Fig. 24)

- | | |
|--|--|
| 1. Register ratio (R_r) tab and programming watt-hour constant (K) tab | 19. Terminal screws |
| 2. "Multiply by" and scale factor (SF) tab | 20. Terminal washers |
| 3. Nameplate screws | 21. Terminal spacers |
| 4. Meter nameplate | 22. Brass nuts |
| 5. Mechanical display | 23. Adapter plate |
| 6. Pointer | 24. Battery holder |
| 7. Electronics plate | 25. Spacers |
| 8. Filter | 26. Retainer |
| 9. Spacers (identified with a groove) | 27. Self-tapping screws for battery holder |
| 10. P. C. board spacers | 28. Lower mounting posts |
| 11. Bezel | 29. Retainer rings |
| 12. Display board | 30. Transformer mounting screws |
| 13. Reset lever | 31. Transformer mounting nuts |
| 14. Logic board | 32. Register nameplate (no serial number, no catalog number) |
| 15. ROM | 33. Ratio assembly |
| 16. Posts | 34. Optics assembly |
| 17. Screws | 35. Transformer |
| 18. Power supply board (contains load control and rate indicator outputs) | 36. Screws |
| | 37. Support spacer (made of LEXAN resin) |

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MP MASTER



MA32646